Genetically modified food and crops: Perceptions of risks

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Declaration

I hereby declare that this thesis has been composed by myself; that the work is my own; and that the work has not been submitted for any other degree or professional qualification.

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Abstract

The debate around genetically modified food and crops has proved to be complex and far-reaching, involving diverse stakeholder groups and many issues. Although the extent of global uptake of GM crops has been substantial (23 countries and 114.65 million hectares by 2007), it is significant that four countries are responsible for 86% of all GM plantings, and that a number of key food markets (for example the EU and Japan) remain largely 'GM-free'. This suggests that there is reluctance on the part of many countries to embrace GM technology. There are likely many reasons for this, but one significant issue is that of the perception of the risks associated with the technology. There is a distinction between risk that exists in the world and that can be measured (objective risk) and risk that is perceived by an individual to exist and that is constructed by them based on their values and preferences. When technical measurement of actual risks is not possible, peoples' own perceptions of risks become important. This thesis aims to investigate the topic of risk perceptions associated with GM food and crops. Different stakeholder groups have been targeted, and a range of methodologies from a variety of disciplines have been employed to investigate what factors can be shown to influence risk perception. A range of factors were identified from existing literature, as having potential impact on risk perceptions. A number of these were investigated, some of which were found to have some influence on levels of risk perception. Results demonstrate that factors influencing peoples' perceptions of risk relating to GM food and crops, include the uncertainty associated with the technology, and trust in regulators, policy makers and others with control over the future development of the technology. Other factors found to be important to levels of risk perception held by different stakeholder groups, were a range of socio-demographic and cultural variables, the relationship between perceived risks and benefits, the equity of impacts, and the influence of third parties. There are a number of implications for the development of the GM debate arising from the findings. First, as there are socio-demographic and cultural factors linked to the perceptions of risk associated with GM technologies in food and agriculture, it is important to recognise that different people will react differently to the technology. Specifically, results from this thesis show that it may be that men, those who are more highly educated, those with a less ecocentric worldview, and those living in urban areas, are likely to respond more favourably to targeted promotional campaigns. As regards the farming community, results show that the first farming adopters are likely to be those who are both owners and tenants, not in an urban fringe location, potato growers, and not barley growers. Second, this thesis provides evidence that third parties are particularly important to farmers, thus it is crucial to recognise that there is potentially a long chain of action and reaction amongst many different

stakeholders and actors impacting on farmers' levels of risk perception, and hence willingness to adopt the technology. Third, results from this research demonstrate that the linked issues of the relationship between risks and benefits, and the equity of (positive and negative) impacts, require that all stakeholders are content that they will receive a share of the benefits (if any) to be derived from the technology, and that neither they nor any other group of stakeholders are unduly impacted by the risks or negative impacts (if any) of the technology. Important here is the recognition that perceptions are as important as actual impacts. Fourth, the issue of trust has been shown by the results obtained by this research to be extremely important to peoples' perceptions of risk. It can be concluded that trust is of wider social and political importance that relates to the need to ensure greater democratisation of decision-making in order to re-establish trust in authorities. In the case of GM food this may require a rethinking of the EU legislation relating to the technology. This also relates to point below about the delivery of messages and education. Information sources must be trusted by those at whom the messages are aimed. More importantly though, if people are to trust decision making processes, there needs to be stakeholder involvement at an early stage of decision making, that allows some impact on decisions taken. In the case of the GM debate it may indeed be too late as decisions about the technology, its applications, the regulatory processes and its inclusion within the food chain are well established. Perhaps the best that can be hoped for is that lessons will be learnt and applied to future technology developments of relevance to the food chain, such as, nano-technology. Finally, this thesis has shown that uncertainty is central to peoples' perceptions of risk. This could be addressed through a combination of additional research into what is uncertain to people, the impacts and implications of the technology, more effective dissemination of existing knowledge, and impartially delivered messages and education strategies from trusted sources that address the concerns that people have about the technology. Importantly however there must be an acknowledgement that uncertainty is not restricted to 'knowledge deficit' but encompasses the scientific uncertainties inherent within the technology, and is framed by the social and cultural values of those whose views are considered.

This thesis uniquely targeted diverse groups and employed a combination of different methods from a variety of disciplines. By doing this the study has increased understanding of the views of two groups (campaigners and farmers) who are crucial to the uptake of the technology, and who are seldom researched in the area of attitudes to GM technologies. The diversity of groups, methods and disciplines brought together in this thesis is important because the issue of GM has proved to be complex and far-reaching, and previous discussions of risk perceptions have been complex and disjointed. All groups investigated here are stakeholders in the process, and as such their views and concerns relating to risk perceptions of GM technologies ought to be taken into consideration.

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Abbreviations

ACRE	Advisory Committee on Releases to the Environment
BSE	Bovine Spongiform Encephalitis
Bt	Bacillus thuringiensis
DERFA	Department for Environment, Food and Rural Affairs
DTI	Department for Trade and Industry
EU	European Union
FSA	Food Standards Agency
FSE	Farm scale evaluations
GM	Genetically modified; genetic modification
GMO	Genetically modified organism
Ha	Hectares
Ht	Herbicide tolerant
NEP	New Ecological Paradigm
NGO	Non-governmental organisation
OSR	Oilseed rape
PCA	Principle components analysis
rBST	Recombinant bovine somatotrophin
TPB	Theory of Planned Behaviour
UAA	Utilisable agricultural area
UK	United Kingdom
USA	United States of America

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Chapter 1: Introduction and structure

1.1 Introduction

The debate around genetically modified food and crops has proved to be complex and far-reaching, involving diverse stakeholder groups and many issues. Although the extent of global uptake of GM crops has been substantial (23 countries and 114.65 million hectares by 2007), it is significant that four countries are responsible for 86% of all GM plantings, and that a number of key food markets (for example the EU and Japan) remain largely ‘GM-free’. This suggests that there is reluctance on the part of many countries to embrace GM technology. There are likely many reasons for this, but one significant issue is that of the perception of the risks associated with the technology.

It is widely understood that perception of risk influences attitudes, decision-making, and thus behaviour, of consumers, producers and others (see for example, Lobb *et al*, 2007; Finucane & Holup, 2005; Frewer, 2003). In the case of the GM debate this is particularly pertinent, as there are many conflicting claims and counter-claims regarding the potential risks and benefits of the technology. GM technology advocates have been frustrated by the choices made by the public and consumers based on risk perceptions that may bear little or no resemblance to actual risks. These perceptions, it is claimed, may be related to a number of factors, including the degree of perception of benefit (which in turn affects the level of risk that people are willing to tolerate), the level of information and knowledge relating to the risk faced, familiarity with the risk, trust in those with responsibility for providing information about, and regulating, the risk, and the sense of self control over exposure to the risk. These issues and others may have, to a lesser or greater degree, played a part in the risk perceptions held by different stakeholders about GM technology and hence the level of acceptance of the technology.

This study examines the issue of risk perceptions associated with the introduction of GM food and crops. The approach has been to study this issue from the point of view of three different groups: the potential consumer in countries throughout the world; those actively opposed to GM food and crops in Scotland; and farmers, potential growers of GM crops, again in Scotland. The research draws on different disciplinary and theoretical approaches, for example environmental economics and the psychometric paradigm, and specific techniques including meta-analysis and Q methodology.

1.2 Aim and objectives

The aim of the thesis is:

- To investigate the factors related to risk perceptions associated with GM food and crops as held by three different stakeholder groups.

The objectives are:

- To present an introduction to the GM debate
- To synthesise and review the literature on risk and risk perceptions
- To carry out secondary research in the form of a meta-analysis of consumer attitudes towards GM food in countries throughout the world
- To carry out empirical research into the attitudes of those people likely to be most opposed to GM food in Scotland
- To carry out empirical research into the risk perceptions of Scottish farmers regarding GM crops
- To carry out qualitative analysis of farmer attitudes towards GM crops in Scotland
- To draw conclusions about the implications of the risk perceptions held by the three different stakeholder groups

Overall, the research will contribute to work in a number of areas, namely:

- Perceptions of risks relating to new technologies
- Attitudes towards GM food and crops
- Farmers' risk perceptions and decision-making

1.3 Structure of the thesis

1.3.1 The practical context – the GM debate

Chapter two presents the background to the GM debate and provides the context for the rest of the thesis. The chapter discusses how the technology has developed and been adopted within agricultural production globally, and provides information about the wider social context, including legislative developments, and consumer acceptance and resistance.

1.3.2 The theoretical context – the risk literature

The theoretical context for the research is discussed in chapter three. The research is based on the premise that in a contentious and polarised debate it is vital to consider viewpoints from a variety of stakeholders, and that in the case of the GM debate, the issue of risk perception is significant for understanding these different viewpoints. The risk literature demonstrates that there are a number of characteristics and dimensions of risk that may help to explain risk perceptions. These include individual control over exposure to the risk, familiarity with the risk, and knowledge about the risk. Issues such as trust in information sources and levels of uncertainty relating to an event, activity or technology may be important for the perception of risk. There are other factors discussed in the literature relating to risk perceptions. For example, it is often claimed that perception of risks may be inversely related to perception of benefit, a premise that may be important for understanding reactions to GM technology in food. Perceptions of risk have also been shown to be related to certain socio-demographic characteristics, such as age, gender and level of education. The literature on farmers' attitudes to risk, and their decision-making relating to the uptake of technological developments, emphasises the importance of various socio-demographic and structural factors thought to be related to the issue of risk perceptions in individuals. Chapter three elaborates on these theoretical concepts and sets the scene for the research that follows.

1.3.3 The approaches

Chapters four, five, six and seven present details of the studies conducted as part of this thesis. The aim of each of the four parts of the thesis was to investigate whether or not the factors identified in the risk perception literature can be said to influence risk perceptions of different stakeholder groups. In order to understand a range of positions the research in this thesis was conducted at different geographical scales using different techniques. The approaches used are considered briefly here.

Meta-analysis

The first part of the study, three meta-analyses, is presented in chapter four. Within the field of environmental economics, valuation techniques are widely used to investigate non-market values, that is values of commodities or attributes for which no actual market exists (for example, landscape, water quality or non-monetary, social attributes of services). When a body of literature has been built up that has sought to value the same non-market good it is possible to conduct a meta-analysis of all such studies in order to derive mean values. Literature relating to meta-analyses of non-market goods and the process involved in conducting a meta-analysis is reviewed in chapter four. The chapter also reports the design, results and analysis of three meta-analyses of valuation studies relating to GM food. The findings are from an analysis of consumer studies at the broadest geographical scale, i.e. globally. Subsequent parts of the thesis focus more narrowly on specific population segments within Scotland.

Postal questionnaire survey instruments

Within the social sciences the use of postal questionnaires for the eliciting of information relating to attitudes, preferences, beliefs and behavioural intentions is commonplace. A key strength of this approach is that it extends the geographical area from where potential participants can be drawn. It is also a relatively low cost method of data collection. The use of postal questionnaires also encourages the involvement of people who might otherwise decline to attend focus group meetings or be interviewed, thus potentially widening the personality 'types' who respond. Postal questionnaires provide scope for rating long lists of items, statements or questions. Two parts of the research conducted for the thesis utilised postal questionnaires.

Chapter five reports the design, results and analysis of a postal questionnaire survey conducted with members of anti-GM campaign groups and environmental non-governmental organisations (NGOs) in Scotland. This population was targeted as the one likely to demonstrate the greatest perception of risk relating to GM food.

Chapter six reports results from another postal survey conducted in Scotland, this time with farmers. The survey sought to address the issue of risk perceptions by examining the characteristics of those farmers expressing a likely intention (or not) to adopt GM crops. The aim was to investigate whether socio-demographic and farm business structural characteristics were related to the potential adoption decision and thus level of risk perception. The survey also elicited a wide range of opinion statements from farmers by utilising open-ended questions. This discourse, collected directly from farmers, was in their own words and hence can be deemed to be self-referent, and formed the basis for a further and more in-depth examination of farmer viewpoints relating to GM crops through the use of Q methodology.

Q methodology

Chapter seven reports details of the design, implementation and results from a Q methodology study that was conducted with farmers in Scotland to elicit their views on the application of genetic engineering to agriculture in Scotland. Q methodology seeks to identify different viewpoints among a specified target population, towards the topic under consideration. It combines qualitative and quantitative aspects and thereby aims at discovering detailed understanding of views while also being analytically robust. The results from this part of the thesis serve to provide additional explanation of the role that risk perceptions and expectations play in the acceptability or otherwise of GM technology in agriculture.

1.3.4 Discussion

Chapter eight of the thesis returns to the ideas laid out in chapter three and summarises whether and to what extent certain factors have been shown to influence the risk perceptions of different stakeholder groups. Hence, in chapter eight the key findings from chapters four to seven are presented, and implications of the research are discussed, both with regard to potential acceptance and adoption of the technology and with regard to policy making.

1.3.5 Conclusions

Chapter nine concludes the thesis, providing a brief summary of the key findings and implications. Finally, recommendations for areas of future research are presented, based in part on an assessment of the approaches reported in the dissertation and areas identified for potential improvement.

Chapter 2: The practical context – the GM debate

2.1 Introduction

This chapter aims to provide an introduction to the GM debate. Topics addressed include a brief history of the development of GM technology in agriculture, and data on the global uptake of the technology. This includes up-to-date figures on adoption of GM technology in crop production, information on current and future technological developments, and on the risks and benefits associated with GM crops. In addition, there is an examination of the development and nature of consumer resistance in the EU and, more specifically, the UK. Hence, consideration is given to the range of issues that have formed part of the debate, for example, environment, health, technology, social, ethical, the role of global business, and sustainability. This is followed by an account of the EU legislative position, and the response of the UK government, major supermarkets and non-governmental organisations (NGOs) to consumer concerns about the technology. The aim is to present the reader with an overview of many aspects of the 'GM debate'.

2.2 What is genetic modification?

Directive 2001/18/EC of the European Parliament and the Council of Ministers defines genetically modified organisms (GMOs) in article two, paragraph two as an "organism (other than human beings) in which the genetic material has been altered in a way that does not occur naturally by mating and/or natural recombination".

There is a range of techniques by which the genetic material may be altered. These include:

- Recombinant nucleic acid techniques whereby new combinations of genetic material are created through the insertion of nucleic acid molecules that have been produced outside an organism. The new external genetic material is inserted into a virus, bacterial plasmid or other vector system, and then incorporated into a host organism where they would not occur naturally;
- Heritable genetic material prepared outside of an organism, is introduced directly into the organism through techniques such as micro-injection, macro-injection and micro-encapsulation;
- Techniques known as cell fusion or hybridisation, whereby live cells are created that contain new combinations of heritable genetic material. The process involves the fusion of two or more cells by means of methods that do not occur naturally (University of Bath, Genetic Modification Safety Committee, 2005).

2.3 Development of the technology in agriculture

The commercial application of GM technology in agriculture began in the 1990s in the USA. The introduction of GM crops started with a small number of crop types, notably soya engineered to be resistant to certain types of herbicide, and oilseed rape (OSR) with similar modifications (known as ht crops, after 'herbicide tolerant'). This has since developed into widespread adoption, in a number of countries, of additional GM crops, including maize and cotton engineered to contain a soil bacterium toxic to certain pests (known as bt crops, after the soil bacterium 'bacillus thuringiensis').

2.4 Current extent of GM cultivation

The current extent of global cultivation of GM agricultural crops is shown in table 2.1. From this it is clear that global coverage has extended beyond the USA, although it is notable that 98.8 million hectares of the total 114.65 million hectares, are grown in only four countries, all in the Americas. Hence it could be argued that adoption remains limited and that there are significant gaps in the GM map. For example, there are still very few European countries growing any GM crops and the acreage in those that are, is minimal. In addition, major economies such as Japan do not yet cultivate GM crops.

Table 2.1 Global area of GM crops in 2004, 2005, 2006 & 2007: By country (million hectares)

Country	2004	2005	2006	2007
USA	47.6	49.8	54.6	57.7
Argentina	16.2	17.1	18.0	19.1
Brazil	5.0	9.4	11.5	15.0
Canada	5.4	5.8	6.1	7.0
India	0.5	1.3	3.8	6.2
China	3.7	3.3	3.5	3.8
Paraguay	1.2	1.8	2.0	2.6
South Africa	0.5	0.5	1.4	1.8
Uruguay	0.3	0.3	0.4	0.5
Philippines	<100,000hectares	0.1	0.2	0.3
Australia	0.2	0.3	0.2	>50,000 hectares
Spain	<100,000hectares	0.1	>50,000 hectares	>50,000 hectares
Mexico	0.1	0.1	>50,000 hectares	>50,000 hectares
Romania	0.1	0.1	>50,000 hectares	<50,000 hectares
Colombia	<50,000 hectares	<50,000 hectares	<50,000 hectares	<50,000 hectares
Honduras	<50,000 hectares	<50,000 hectares	<50,000 hectares	<50,000 hectares
Portugal	--	<50,000 hectares	<50,000 hectares	<50,000 hectares
Germany	<50,000 hectares	<50,000 hectares	<50,000 hectares	<50,000 hectares
France	--	<50,000 hectares	<50,000 hectares	<50,000 hectares
Czech Republic	--	--	<50,000 hectares	<50,000 hectares
Slovakia	--	--	<50,000 hectares	<50,000 hectares
Poland	--	--	--	<50,000 hectares
Chile	--	--	--	<50,000 hectares
Iran	--	<50,000 hectares	<50,000 hectares	--
Total	**81.0**	**90.0**	**102.0**	**114.65**

Source: James, 2005; James, 2006; James, 2007

To provide some idea of the significance of the cultivated area of GM crops in the EU consider the following EU data. In 2004 there were 58,000ha of GM crops in EU15 (European Commission, 2005). The total utilisable agricultural area (UAA) of the EU15 in 2004 was 130,097,000ha, and the cereal area in EU15 in 2004 was 37,471,000ha (European Commission, 2004). GM crops were therefore grown on approximately 0.15% of cereal area.

In addition, table 2.2 demonstrates that, as of 2005, there were limited varieties of GM crops being grown commercially throughout the world. As shown, 60% of all GM crops grown globally were ht soybean, and 80% were soybean and maize. Indeed only four crops were grown commercially in a GM form. It is clear that cultivation of GM crops is limited both geographically and varietally.

Table 2.2 GM crops 2005

Crop	Million hectares	% GM
Herbicide tolerant soybean	54.4	60
Bt maize	11.3	13
Bt/herbicide tolerant maize	6.5	7
Bt cotton	4.9	5
Herbicide tolerant oilseed rape	4.6	5
Bt/herbicide tolerant cotton	3.6	4
Herbicide tolerant maize	3.4	4
Herbicide tolerant cotton	1.3	2
TOTAL	**90.0**	**100**

Source: James, 2005

2.5 Benefits and risks of GM crops

The first type of modified crops, commonly known as ht crops, offers some benefits to farmers through the simplification of weed control. Farmers growing ht crops can use the application of one, broad-spectrum herbicide that kills most weeds but leaves the crop unharmed, as opposed to multiple applications of different herbicides at different times of the growing season. The cultivation of ht crops can also have advantages for soil structure, as there is less mechanical disturbance to the soil throughout the growing season. Studies with farmers (see for example, Oreszczyn, 2005) have confirmed the benefits for farm management. Farmers identify advantages of ht crops as being simplified management, greater flexibility because of there being a wider window available for spray applications, and less spraying, which has cost, environmental and time advantages.

The second type of modification, known as bt crops, again makes crop management easier for the farmer, to a large extent removing the need for pesticide applications through spraying. This is also claimed to have environmental and health benefits, by reducing the need for chemical use. Since these initial introductions, crops with ‘stacked’ modifications (e.g. combining both ht and bt modifications) have been developed. There are expectations that GM crops will be developed that are frost-resistant, drought-resistant, salt-tolerant, vaccine-containing, vitamin-enhanced and others, but while some of these modifications are being researched they are yet to be made commercially available.

However, while some espouse the benefits of GM crops and see them as an environmentally friendly improvement in plant breeding, others see them variously as a risk-management problem, or as pollutants in themselves (Levidow & Carr, 2007). Thus there are different ways of framing GM crops, in terms of risks and benefits. Levidow and Carr suggest three risk frames: one from the perspective of proponents from within the industry, a second from the managerial position of regulatory agencies, and the third from those opposed to the technology, such as environmental NGOs. Thus the biotechnology industry has promoted GM crops as an extension of selective breeding, claiming that GM crops bring environmental, agronomic and economic benefits. In contrast, according to opponents, GM crops pose risks which are unmanageable. According to environmental NGOs, GM crops reinforce the problems of intensive agriculture (Levidow & Murphy, 2003) and offer unpredictable and uncontrollable risks, while increasing farmers’ dependence on multinational agri-biotechnology companies. In this case, GM crops are seen as pollutants and as undermining more environmentally-friendly, less-intensive agriculture. Critics of GM crops fear that they present the risk of a ‘genetic treadmill’, such that ht crops will spread herbicide tolerance to related plants and create ‘superweeds’, thus requiring new developments to overcome the problems arising. Similarly, bt crops are expected to create resistant pests. The risk frame of regulatory authorities (certainly in the EU) has been one of precaution but one in which GM crops are ultimately viewed as presenting identifiable and manageable risks. According to the European Commission, the regulatory framework aims to protect human health and the environment, provide legal certainty for operators, and offers consumers choice.

The potential risks of GM crops may also be framed differently across countries. Thus the Austrian government sees GM crops as a threat to their subsidised organic agriculture, whilst in Italy the government views GM crops as an economic risk to traditional agriculture. In Denmark the risks are viewed as being directly related to ht crops and expectations that increased use of the relevant herbicides could impact on measures to reduce inputs to agriculture that impact on groundwater quality (Levidow *et al*, 2000).

Further concerns have emphasised potential risks for non-target insect species, including lacewings and monarch butterflies (Jasanoff, 2000). These concerns have been highlighted by scientific studies that suggested harm may occur to these insects from bt crops (Hilbeck *et al*., 1998; Losey *et al*., 1999).

The risk debate about GM crops is further complicated by the fact that opponents and proponents may agree about the potential impacts (herbicide and pest resistance, for example) but disagree about what are acceptable impacts, and to what production systems GM crops should be compared. Thus they may be no worse than long-standing intensive agricultural systems, say proponents, but equally they may be considered much worse than less-intensive systems, say opponents. Thus the baseline against which GM crops are measured is important and varies between groups (Murphy *et al*, 2006).

Finally, it is feared by some that the introduction of GM crops may lead to the loss of biological and genetic diversity. Genetic modification, it is thought, may increase the likelihood that an organism will become an invasive species. Some introduced plant species become invasive and impact negatively on their new habitat. There is a lack of knowledge about why some plants become problematic invaders while others do not. One risk associated with GM crops is therefore an inability to predict what modifications might cause a plant to become a successful and damaging invasive species (Aslaksen & Myhr, 2007).

2.6 GM technology and consumer concerns

In the previous section consideration has been given to the benefits and risks of introducing GM crops into the environment. As the commercialisation of GM crops developed, concerns about such impacts, and others, began to be voiced by consumers and protest groups. In the UK the topic of GM food began to receive public attention with the commercial availability of GM tomato puree in 1996. As concerns about GM food increased towards the end of the 1990s, there was considerable media coverage of, and high profile campaigns by certain protest groups against, the process of mixing GM and non-GM soya ingredients in many processed food products. The soya came mainly from the USA where there had been no attempt to keep GM and non-GM soya supply chains separate and hence producers were unable to provide traceability and market segmentation of the two types of soya, something to which many EU consumers objected (Consumers' Association, 2002; Greenpeace, 2006).

The continuation of consumer concerns following the peak at the end of the 1990s is demonstrated by the results of a UK Food Standards Agency (FSA) annual consumer survey that contains a number of questions relating to GM foods. Table 2.3 and figure 2.1 show that responses to the five questions asked yearly since 2000 have changed little over time in terms of the amount of concern expressed. The year 2000 represented a high point in the level of concern, but subsequent years reveal a relatively consistent amount of concern. For example, the percentage of people who agreed that they had concerns about the safety of foods with GM ingredients was 21% in 2001 and 19% in 2005. Likewise, the percentage of people saying that they had concerns about the issue of GM foods was 38% in 2001 and 37% in 2005.

Table 2.3: Responses to questions contained in annual FSA consumer survey

Question	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Q1 Have concerns about safety of foods with GM ingredients	27%	21%	23%	25%	25%	19%
Q2 Concerned about the issue of GM foods	43%	38%	36%	38%	38%	37%
Q3 Concern about GM food issues affects eating habits	73%	72%	74%	78%	N/A	N/A
Q4 Usually look for information on food labels about whether the product is of GM/non-GM origin	25%	17%	20%	18%	23%	16%
Q5 Would like more information about GM food	44%	29%	28%	28%	29%	22%

Note: N/A – Question not asked
Source: Food Standards Agency, 2001; Food Standards Agency, 2002; Food Standards Agency, 2003; Food Standards Agency, 2004; Food Standards Agency, 2005; Food Standards Agency, 2006.

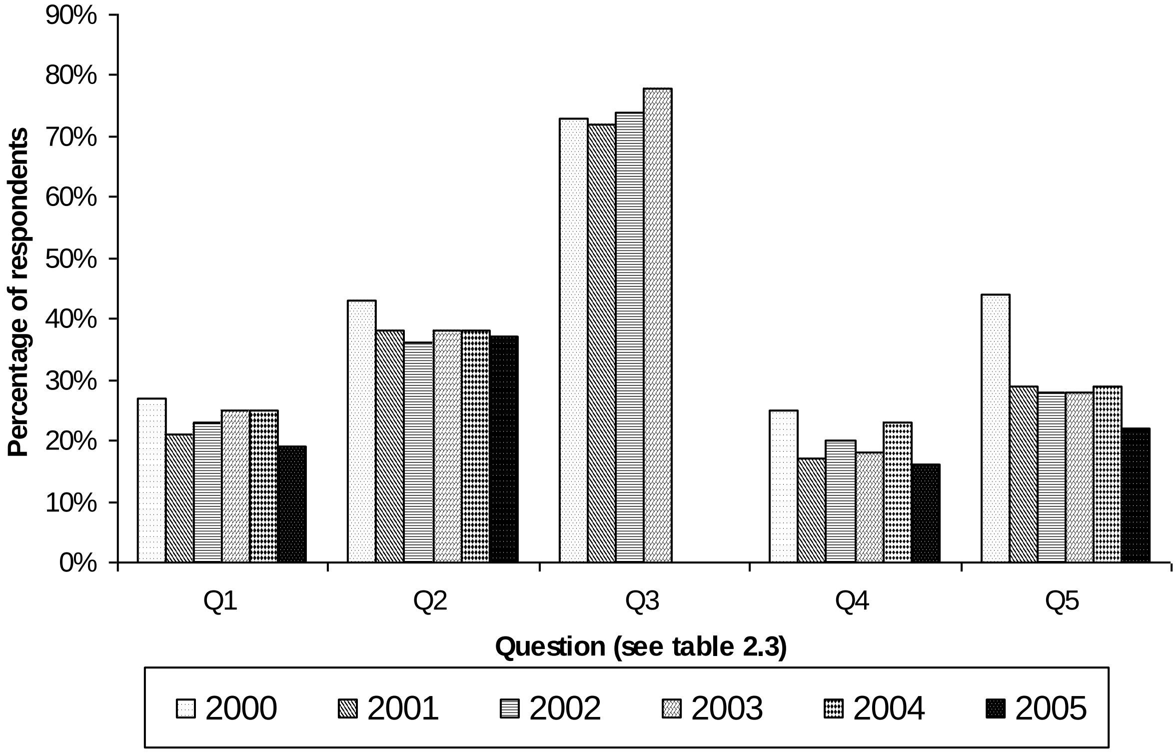

Figure 2.1 Percentage respondents to FSA annual consumer survey questions

Clearly, UK consumers continue to have concerns about GM foods. Here, consideration is given to the nature of those concerns. The GM debate has encompassed a wide range of issues and these are considered briefly below, and in detail in chapter three. At this point it suffices to state that issues of concern include, but are not limited to:

- Consumer choice and hence the right to choose whether or not to be exposed to a potentially risky new technology
- Multinational corporate control of the global food chain and the potential risks this presents to the livelihoods of farmers and the choice of the consumer
- Potential and unforeseen health risks, for example new allergens
- Concerns over potential environmental risks, for example, cross-fertilisation with wild relatives, and loss of biodiversity
- Ethical concerns that genetic manipulation of plants is wrong.

There are a number of previous studies that confirm the existence of the consumer concerns mentioned above. For example, a number of authors refer to unpredictable health risks (Lemkow, 1993; Olubobokun & Phillips, 2004; Isaacs, 2001; Subrahmanyan & Cheng, 2000; Verdurme & Viaene, 2003), environmental safety risks (Olubobokun & Phillips, 2004;

Isaacs, 2001), the economic, social and ethical impacts of GM technology (Olubobokun & Phillips, 2004), and the structure of agri-business (Isaacs, 2001). Others mention the potential for long-term environmental effects (Lemkow, 1993), risks to future generations (Poortinga & Pidgeon, 2003; Rosati & Saba, 2000), and long-term food safety issues (Grove-White *et al*, 1997). These long-term effects are expected in many instances to be largely unpredictable. Unpredictability is related to the sense of a lack of personal control over exposure to the risk (Grove-White *et al*, 1997; Poortinga & Pidgeon, 2003). A number of studies mention in more detail the concerns about the environmental impact of GM technology. For example, it is thought that GM technology may threaten the balance of nature and the so-called ecological equilibrium (Lemkow, 1993). Further, there are objections to the manipulation of nature (Charles, 2001), concerns about the impact of human action and technology on nature (Gaskell *et al*, 2003) and worries about the disappearance of species (Lemkow, 1993). In addition mention has been made of specific concerns about the potential for cross-pollination from GM crops to wild species (Charles, 2001).

2.7 The EU legislative response to consumer concerns

In 1998, as public disquiet and protest grew over the way in which GM products had been introduced (see section 2.6), there was a period of six years during which no new applications were considered for the importation or cultivation of GM food or crops in the EU. During this period, legislation was proposed, debated and amended, and finally agreed and implemented. The legislative framework on GMOs in the EU has been operational since April 2004. There are three main legal instruments of relevance here. The first relates to the release of GM crops to the environment, either for research purposes or commercial cultivation. The second relates to the placing on the market of food or animal feed from GM sources. The third relates to the labelling of GM food products or products containing GM ingredients. The details of these legislative instruments are as follows:

2.7.1 Directive 2001/18/EC

The release of GMOs into the environment for experimental purposes (for example, for field testing) is governed by Part B of Directive 2001/18/EC on the deliberate release into the environment of GMOs. Part C of the same Directive controls the placing on the market of products containing or consisting of GMOs for example for cultivation, importation or processing into industrial products.

In the Directive the deliberate release of a GMO into the environment refers to the introduction of a GMO with no measures being taken to restrict interaction between the GMO and the environment or general population. As noted, such a release may be carried out for experimental purposes or commercial cultivation. During the authorisation procedure there are a number of requirements that are laid down in the Directive. These are as follows:

- An environmental risk assessment must be carried out to identify and evaluate potential adverse effects of the GMO;
- There is a mandatory requirement to provide information to the public;
- There is a requirement to provide information to allow the identification and detection of GMOs to enable inspection and control;
- Consultation with the European Food Safety Authority (EFSA) is obligatory;
- There is an obligation to inform the European Parliament on decisions to authorise the release of GMOs; and
- There is a requirement to ensure that the Council of the EU can adopt or reject a Commission proposal for authorisation of a GMO by qualified majority.

Once the product is authorised and placed on the market there are mandatory post-market monitoring requirements, including monitoring of the long-term effects associated with the interaction with other GMOs and the environment. There is also a requirement for Member States to ensure labelling and traceability at all stages of the placing on the market, according to the process outlined in Regulation 1830/2003 on traceability (see below). First approvals for the release of GMOs are limited to a maximum of ten years.

2.7.2 Regulation (EC) 1829/2003

The placing on the market of food or animal feed containing, consisting of, or produced from GMOs, is governed by Regulation (EC) 1829/2003 on GM food and feed. This regulation lays down the procedures for the authorisation and supervision of GM food and feed. The procedures and requirements (for example for environmental risk assessment and information provision) are in many instances according to those required under Directive 2001/18. The regulation also includes some provisions for labelling.

Non-GM products may be accidentally contaminated by GMOs during cultivation, harvesting, storage, transport or processing, and the regulation also addresses this issue. The legislation sets a limit of 0.9% GM content, above which conventional food and feed must be labelled as products consisting of GMOs, containing GMOs or produced from GMOs. Non-GM products that have been “contaminated” by authorised GMOs are therefore not subject to traceability and labelling requirements if they contain traces of these GMOs below a limit of 0.9%. This is dependent on the presence of this material being “adventitious or technically unavoidable”, that is, not having been added deliberately. In addition, the regulation allows the presence of GM food or feed that are not yet authorised, up to a maximum content of 0.5%, provided they have received a positive assessment by the EFSA in terms of safety for human health and the environment. Above 0.5% GM content, it is prohibited to put an unauthorised product on the market, even if a positive safety assessment has already been provided.

2.7.3 Regulation 1830/2003

GMOs and food products derived from GMOs that are approved under Regulation (EC) 1829/2003 and placed on the market, must comply with labelling and traceability requirements. These requirements are found in both Regulation (EC) 1829/2003 and in Regulation (EC) 1830/2003 concerning the traceability and labelling of GMOs, and the traceability of food and feed products produced from GMOs.

Regulation 1830/2003 covers products containing or consisting of GMOs that have received EU authorisation to be placed on the market. Examples include GM seeds and shipments of whole GM grain, such as soybean and maize. The regulation also covers food and feed derived from a GMO, such as flour produced from GM maize. The traceability rules require persons who place a product on the market, or those who receive a product placed on the market within the EU, to be able to identify the companies to which the products have been supplied or their supplier. The traceability requirement varies depending on whether the product consists of or contains GMOs (Article four), or has been produced from GMOs (Article five).

According to Article four of the Regulation, relating to a product consisting of or containing GMOs, suppliers must provide with the product, information in writing that it (or some of its ingredients) contains or consists of GMOs. They must also provide information of the unique identifier(s) assigned to the GMOs.

In Article five of the Regulation relating to products produced from GMOs, it is stated that suppliers must provide with the product, written information about each of the food ingredients that are produced from GMOs or about each of the feed materials or additives that are produced from GMOs. In both cases (Articles four and five), operators must hold the information for a period of five years and make the information available to the public authorities on demand.

In addition to these traceability provisions, Regulation 1830/2003 also sets out labelling requirements for GM products. These state that all pre-packaged products consisting of or containing GMOs, must be labelled: "This product contains genetically modified organisms" or "This product contains genetically modified [ingredient]". For non pre-packaged products offered to the final consumer or to mass caterers, these words must appear where the product is displayed.

In addition to the Directive and the two regulations described above, there are two further legislative instruments. The "contained use" of GM micro-organisms, for example laboratory research, is regulated by Directive 90/219/EC. Unintentional movements of GMOs between Member States, and exports of GMOs to third countries, are governed by Regulation (EC) No 1946/2003 on transboundary movements of GMOs (European Commission, DG Health and Consumer Protection).

2.8 UK government response to consumer concerns

Because of continuing public disquiet over the technology (demonstrated for example by the FSA survey results reported in section 2.6), in 2003 the UK government attempted to address some of the public concerns by organising a national process of formalised debate known as 'GM-Nation?' (Heller, 2003). During this process 675 public meetings were organised, involving somewhere between 8,000 and 20,000 people over six weeks in the summer of 2003. In addition, 10 focus groups were organised to reach those not inclined to attend the public meetings. Seventy-seven people were involved in the focus groups. The formal report of the process claimed that the public meetings had largely been attended by people with prior interest in the topic, often those strongly opposed to the technology who were likely to be a member of an environmental campaign group. This was taken to mean that their views were not representative of the 'general public', and in the reporting process, considerable weight was placed on the outcomes of the focus groups that involved people with little interest in the subject and no prior views of the technology. There was also a postal survey available at the public meetings and on request. This was completed and returned by 36,557 people. It revealed that 93% of respondents agreed that not enough is known about the long-term health effects of GM food, and that 91% agreed that there are potential negative effects of GM crops on the environment. Clearly, this demonstrates a high level of perceived risk.

At around the same time as the GMNation? public debate was reported, the results of farm scale evaluations (FSEs) (Firbank *et al*, 2003), the Strategy Unit cost benefit study (Cabinet Office Strategy Unit, 2003), the science review (GM Science Review Panel, 2003) and the recommendations to the government from ACRE (Advisory Committee on Releases to the Environment, 2004) were released to the public domain. Each of these exercises contributed to the debate, and between them discussed in detail the costs, benefits, risks, threats and opportunities arising from the technology.

The FSEs were conducted at 266 sites across the UK and three crops were included. These were OSR, beet and maize, all modified to be ht. The purpose of the FSEs was to investigate the impact of weed management strategies under GM ht crops on weeds, weed seedbanks and certain insect populations. The study concluded that in the case of beet and OSR the GM varieties would be worse for wildlife (given the same crop management as occurred under the trials). In the case of the maize crop, it was found to provide advantages for wildlife and hence was approved for cultivation.

The aim of the Strategy Unit cost-benefit study (Cabinet Office Strategy Unit, 2003) was to provide an analysis of the costs and benefits of potential commercial cultivation of GM crops in the UK. They also developed scenarios to explore possible futures. The conclusions were that the key drivers of change within the GM debate were likely to be the nature of regulation and the extent of consumer resistance or acceptance.

The main point concluded by the Science Review (GM Science Review Panel, 2003) was that GM crops are not homogenous and as such each needs to be considered on its own merits. Thus it was recommended that decisions relating to GM crops should be made on a case by case basis. Both the Science Review and the ACRE recommendations (Advisory Committee on Releases to the Environment, 2004) concluded that ht OSR and beet managed under the conditions applied during the FSEs would have detrimental environmental impacts but that ht maize would not.

As noted, these exercises contributed to the debate, and between them addressed the issues of costs, benefits, risks, threats and opportunities arising from the technology.

However, the extent to which the results contributed to the development of the legislation is unclear, since the EU legislative process was all but finalised by the time the UK research and consultation activities were completed. Nevertheless the FSEs are recognised as having contributed significantly to the understanding of how different crop management processes can affect issues such as weed seedbanks and certain insect populations, and the fact that it would be necessary to consider GM crops on a case by case basis. The cost-benefit study represents a good example of a large-scale stakeholder consultation exercise and provided a thorough overview of the issues connected to the GM debate. In addition, the GMNation? debate is considered to have been an important consultation exercise in its own right and one that has provided useful lessons as to how large-scale public consultation can best be handled.

However, although the GMNation? debate was positively viewed as being an important attempt at public consultation, it has also been retrospectively criticised for many failings in terms of objectives, delivery and impact. As noted above, the participants in the open public meetings and those who completed the questionnaire, were not considered to be representative of the general public. Pidgeon *et al* (2005) claim to have validated this by completing a statistically representative survey shortly after the debate that found considerably different views. Thus the problem of self-selection inherent in any public meeting or open on-line survey was considered to have skewed the results. That self-selection is a quality of any open meeting seems not to have been foreseen.

Other criticisms of the GMNation? debate relate to the length of time available for completion (five weeks) and the budget allocated (£500,000). Both are considered to have been inadequate for a truly thorough and meaningful national debate (Irwin, 2006).

Nevertheless, GMNation? was viewed in a positive light for allowing members of the public to be involved in the ‘discussion’ about issues relating to GM crops (Irwin 2006). However, while conducting consultation at ‘arms length’ from government is considered positive since it ought to have enabled impartiality of views and objective interpretation, it also put some distance between the consultation exercise and the process of policy-making, which could be viewed negatively. How these two aims could have been reconciled is unclear.

One of the indicators of success proposed by the GMNation? sponsors is given by Rowe *et al* (2005) as: The extent to which the report from the debate “could reasonably be said to have had an impact on Government”. However, Rowe *et al* note that the influence of the debate can only be considered to be minor because policy was subsequently set with no clear input from the debate results. In evaluating GMNation? Rowe also drew on evaluation criteria presented by Rowe and Frewer (2000), which included representativeness. As already noted, the participants were not particularly representative of the wider public.

GMNation? has also been criticised for containing fundamental design flaws. For example, it was intended to be both a forum for deliberation and a research tool able to elicit the public's true attitudes towards biotechnology. These two goals, according to Lezaun and Soneryd (2007), proved difficult to combine.

Overall, while GMNation? has been viewed positively for the attempts made at consulting the public at a national level about a high profile social, environmental and technological issue, it has been subjected to extensive criticism for the failings outlined above. Not least must be the fact that findings could not be utilised in policy making (relating for example to the approvals process for GM crops in the EU) because of the timing and the hierarchical decision-making on GM crops at European level.

The opportunity for combining public, economic and technical appraisal of GM crops was missed while these government evaluations were running concurrently (Irwin, 2006). There was no attempt at interaction between strands and thus no chance to react to each others' findings. Thus the cost benefit study results were neither available for consideration in GMNation? nor able to incorporate public concerns arising from GMNation?. Likewise, the science review and the farm scale evaluations proceeded independently.

2.9 The supermarkets' response to consumer concerns

When consumer concerns first arose following the introduction of GM tomato puree the supermarkets reacted by withdrawing the product. Consumer concerns have continued to influence supermarket decisions relating to GM products and product ingredients for around a decade. Thus, despite the approval of products for commercial sale across the EU (for example, tinned sweetcorn) the major supermarkets in the UK claim to have ensured GM-free ingredients in all of their own-brand products. The exception to this rule lies in the use of GM animal feed products for livestock providing meat and animal-derived products.

2.10 NGO response to consumer concerns

In line with continued consumer unease about the issue, the Friends of the Earth website contains a table detailing animal derived products on sale in the major supermarkets and whether or not they are sourced from animals fed GM-feed (table 2.4). The topic of the role of NGOs in the 'GM debate' is discussed in more detail in chapter five. The intention of this is presumably to provide consumers with the choice of avoiding products derived from animals fed on GM-feed, something that the labelling legislation does not facilitate.

Table 2.4: Supermarket claims about animal derived products and their GM-feed status

Supermarket	Milk	Other dairy	Fresh pork	Fresh beef	Fresh lamb	Eggs	Chicken	Turkey	Farmed fish
Marks and Spencer	√	X	√	√	√	√	√	√	√
Co-op	X	X	√	X	X	√	√	√	√
Waitrose	X	X	X	X	X	√	√	√	√
Sainsburys	X	X	X	X	X	X	√	√	√
Morrisons	X	X	X	X	X	√	√	√	√
Asda	X	X	X	X	X	√	√	√	√
Somerfield	X	X	X	X	X	√	√	√	√
Iceland	X	X	X	X	X	√	√	√	√
Tesco	X	X	X	X	X	√	√	√	√
Budgens	X	X	√	X	X	X	√	X	X

√ Specifies that GM animal feed must not be used
X No guarantee that GM animal feed is not used
Source: Friends of the Earth, 2006

2.11 Conclusions

This chapter has provided a picture of the current situation as regards the development, commercialisation, benefits and risks of GM crops. Also, an explanation has been given of why and how consumer resistance has developed. The chapter presented a brief discussion of some of the issues that lie behind consumer concerns, issues that are addressed in more detail in chapter three. In addition, and in order to demonstrate the impact of consumer concerns, this chapter presented an outline of the EU legislative response, the UK government response, and the response of the supermarkets and NGOs. It could be argued that the actions reported would not have occurred if consumer groups had not raised concerns about the potential risks of the technology, thereby revealing the ability of those groups to influence the introduction of new technologies (Tait & Chataway, 2007). In the next chapter there is a discussion of approaches and theories related to understanding perceptions of risk. It follows on from this chapter as the issue of risk underlies many of the concerns described above.

Chapter 3: The theoretical context – Risk and risk perceptions

3.1 Introduction

Following an introduction to the subject of risk and how it has been defined within a range of disciplines, the aim of this chapter is to review and synthesise the literature relating to risk perceptions, focusing on the factors thought to influence perceptions of risk of members of the public (consumers) and farmers.

There is a wide range of factors from across different disciplines that, it is claimed, have an influence on peoples' perceptions of risk. These factors will be reviewed and discussed in some detail, with illustrations from previous studies. Following this there is a review of studies that have considered the issue of risk perceptions where they relate specifically to GM technology. The purpose is to begin to consider which factors might be relevant when considering risk perceptions relating to GM food. A further section of this chapter presents a review of studies that have considered the factors that influence risk perceptions, decision-making and technology adoption by farmers. The chapter ends with a brief summary of the various factors thought to influence risk perceptions, and a description of the structure of the remainder of the thesis.

3.2 Introduction to risk

3.2.1 Origins of the notion of risk

The origins of the idea of risk are subject to debate (Taylor-Gooby & Zinn, 2006). Nevertheless, it has been claimed that "risk has always been part of human existence" (Renn, 1998). The origins of the word risk have been variously identified as having Arabic roots (the word risq), Latin roots (the word risicum), German roots (from the 16th century), Spanish or Italian roots (the word risco), Greek roots (the word rhiza) or indeed Portuguese (Taylor-Gooby & Zinn, 2006; Althaus, 2005). The idea of risk has been connected to developments in sea-faring, specifically sailing into uncharted waters, to trading, commerce and emerging insurance and financial markets (Taylor-Gooby & Zinn, 2006). It has been further argued that sixteenth century courtiers and algebra experts derived the modern idea of risk and probability by applying mathematical knowledge to gambling (Mairal, 2008). The same author claims that the best example of an early narrative on risk was by Daniel Defoe in a book published in 1720 called 'A Journal of the Plague Year', elaborating the potential risk associated with a second plague happening in London, based on his own experiences in the 1660s. The relevance of this is that it showed how past experience could be used to try to understand and predict potential future risks. According to Giddens (1999), the modern idea of risk is only relevant when a society is 'future-oriented' and when people believe they can have control over what happens in the future.

3.2.2 Definitions of risk

While there may be "no commonly accepted definition for the term risk" (Renn 1998), there is no shortage of definitions. A dictionary definition of the word is given as:

1. The possibility of suffering harm or loss.
2. A factor, thing, element, or course involving uncertain danger; a hazard (*http://www.thefreedictionary.com/risk)*.

A widely used technical definition of risk is: Risk = Hazard x Exposure (Greene, no date). Risk is a probabilistic notion and scientists gave the first definition of probability in 1654 (Mairal, 2008). This lead to the simple framing of risk in terms of 'When A and B connect, C could happen', as shown in figure 3.1.

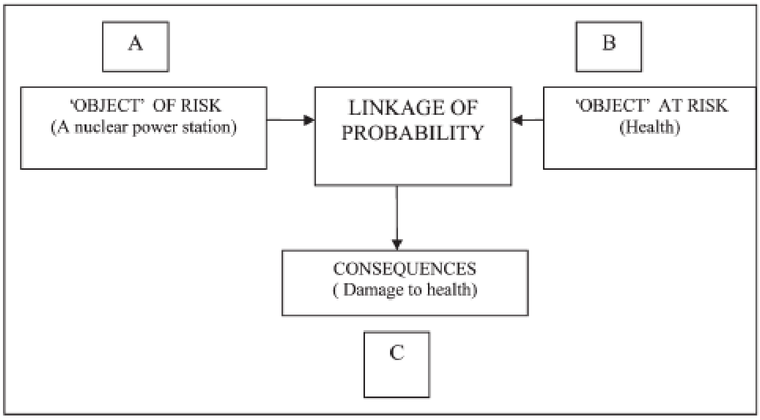

Figure 3.1: Risk frame

Source: Mairal, 2008, p43

Drawing on those early scientific understandings of risk and probability, in statistics, risk is often connected to the statistical probability of the occurrence of an undesirable event. Usually the probability of that event, and some assessment of its expected harm, are combined into an expected value for that outcome. Thus, in statistical decision theory, the risk function of an estimator $\delta(x)$ for a parameter θ, calculated from some observables x is defined as the expectation value of the loss function L:

$$R(\theta, \delta(x)) = \int L(\theta, \delta(x)) \times f(x|\theta)\, dx$$

where:

- *δ(x)* = estimator
- θ = the parameter of the estimator

(Wikipedia, 2007).

The OED definition of risk (quoted in Adams, 1995) is “unquantifiable danger, hazard, exposure to mischance or peril”. The OED provides further definitions that encompass both negative and positive elements of risk: “to hazard, endanger; to expose to the chance of injury or loss”; “to venture upon, take the chances of” (Althaus, 2005). Although the idea that risks can be positive has been largely lost in popular ideas of what risk is, Renn (1998) provides another definition that incorporates a certain ambiguity as to the positive or negative nature of consequences: “Risks refer to the possibility that human actions or events lead to consequences that affect aspects of what humans value”.

Similarly to Renn, Jaeger *et al* (2001) define risk as “a situation or event in which something of human value (including humans themselves) has been put at stake and where the outcome is uncertain”. They argue that this definition embeds the conventional definition of risk (as the probability of an occurrence or event multiplied by the value of the outcome of that event) but also captures the idea that humans exist in uncertain natural and human-made environments. It is the idea of uncertainty that has achieved primary importance to the idea of risk in modern society. Risk is therefore concerned with uncertainties, possibilities, chances or likelihood of events, often as consequences of some activity or policy (Taylor-Gooby & Zinn, 2006). Of relevance here is the notion that issues of uncertainty are embedded in technological development, an idea that is central to the writings of Ulrich Beck.

Ulrich Beck has become one of the most debated writers in social science texts on risk. He elaborated a theory of risk that questions the suitability of earlier sociological approaches that were used to explain the workings of society, for seeking to understand contemporary technological society, which he sees as being fundamentally defined by notions of risk. Beck’s sociology of risk is of interest to those concerned with understanding the complex impacts of invisible hazards such as climate change, pollution, the effects of

GM foods, and diseases such as BSE. In Beck's idea of 'risk society' he argues that modern society, like no other, is a world of risk, the like of which no earlier cultures have known. He argues that it is the concept of risk itself that captures what is new and different in contemporary society. Beck contends that it is the failure of industrial society to control the risks it has created that has lead to an intense awareness of risk in modern society, such that it runs through everyday life and behaviour, and is an ever-present concern in all activities and choices. Beck's theory elevates risk to such prominence that other social forces are by implication downgraded in conceptual importance (Elliot, 2002).

When considering 'what risks are' Beck states that they are not the same as destruction, do not refer to damages incurred and cease to exist when the potential catastrophe actually occurs. The discourse of risk therefore begins where trust in security ends. The concept of risk thus characterises an intermediate state between security and destruction, where the perception of threatening risks determines thought and action. Ultimately it is cultural perception and definition that constitute risk (Beck, 2000). When Beck introduced the notion of "risk society", he pointed to the concept of 'disaster risk' which he sees as being inextricably associated with the processes of industrialisation. The disaster risk concept relates to highly unlikely but extreme, catastrophic events (Botterill & Mazur, 2004).

Beck also claimed that there are likely unforeseeable negative side effects of modern large-scale technology and industrial processes, that will probably outweigh the intended positive consequences. However, he argued that technological society gets around this problem in a number of ways. First, risks are spread over large and diverse populations, and any unforeseen negative side effects are externalised to third parties thus ensuring that profits of private enterprises are not undermined. Further, he argues that accountability for negative impacts are largely absent because industry and government have developed risk management procedures that obscure responsibility for risks. Thus technical risk assessments legitimise the creation of risk, and because risk assessment procedures are in place people accept threats that they otherwise would not (Renn, 2008).

Central to Beck's idea of risk is the notion that risk in modern societies is fundamentally different to risk in traditional societies. For example, he claims that, unlike risks in pre-modern societies, the modern technological risks cross all known boundaries, including national, social and cultural, and therefore have the potential to impact everybody. Thus, perhaps one of the most important characteristics of modern risks, according to Beck's risk society theory, is that risks are democratic (Zinn & Taylor-Gooby, 2006; Jones *et al*, 2006). He also claims that the risk assessment processes, techniques and tools that exist are neither accurate nor adequate. As noted above, Beck also believes that there is a fundamental lack of accountability associated with the development and use of technologies and the risks and side-effects arising. Thus, people are exposed to risks without choice and with no obvious route to specific organisations or individuals to claim compensation should harm arise (Renn, 2008).

So overall, in Beck's risk society theory, modern society is differentiated from earlier societies by the nature of risk and the ways in which responses follow. Thus, modern risks are believed to be primarily man-made, frequently undetectable through human senses, and therefore able in many cases to be detected only through the use of high-technology such as geiger counters for measuring radioactivity (Alaszewski, 2009). The modern day challenge for people is to learn to live in societies where risks are insidious and beyond comprehension and control, and where expert advice can be contradictory and subject to change.

Ultimately, for Beck, the modern age is defined by a universal concern about hazards in contemporary life, and about the vulnerability of both the human species and the wider environment (Jaeger *et al*, 2001).

3.2.3 Approaches to risk from across the social sciences

Ulrich Beck's thesis on risk is only one understanding of the issue. From within the social sciences there is a range of approaches to understanding risk, formed on different theoretical bases. For example, as will be briefly described, psychologists, economists, sociologists and cultural theorists approach the study of risks differently. By way of illustration, Althaus (2005) lists a range of disciplines and summarises how each views risk (table 3.1). According to the author, all view risk differently. Thus while risk is considered by science to be and objective reality, it is considered by anthropology to be a cultural phenomenon.

Table 3.1: How disciplines view risk

DISCIPLINE	HOW IT VIEW RISKS
Logic and mathematics	As a calculable phenomenon
Science and medicine	As an objective reality
Anthropology	As a cultural phenomenon
Sociology	As a societal phenomenon
Economics	As a decisional phenomenon, a means of securing wealth or avoiding loss
Law	As a fault of conduct and a judicable phenomenon
Psychology	As a behavioural and cognitive phenomenon
Linguistics	As a concept
History	As a story
The arts (literature, poetry, music, theatre, art etc	As an emotional phenomenon
Religion	As an act of faith
Philosophy	As a problematic phenomenon

Source: Althaus (2005)

Social science definitions and understandings of risk start from different theoretical bases. In economics, approaches to risk begin with presuppositions that people behave as ‘rational’ actors (the economic perspective of risk is considered in more detail in chapter four); in psychology, assumptions are built on the idea that the individual is the focus of analysis. Thus, from a psychological perspective, approaches to risk are typically tackled at an individual level. Importantly, social psychology has had a significant impact on the study of risk in the social sciences by bringing in psychometric contributions from social surveys. In sociology, risk is studied from the position that aspects of society such as culture, institutions or family are most relevant. Sociological approaches to the study of risk assume that social action is shaped by institutions and culture, rather than being directed by rational planning (as in economics) or influenced by individual emotions or cognition (as in psychology). This has led to approaches to the study of risk that focus on the rise of the modern state and modern forms of power, changes in the economy, experiences of work and family life, cultural shifts and the impact of new technologies (Taylor-Gooby & Zinn, 2006).

Another approach to studying risk within the social sciences is laid out in cultural theory, according to which risk is culturally constructed (Adams, 1995). Cultural theorists expound the view that where scientific fact does not provide certainty, people are guided by assumptions, inferences and beliefs. In polarised debates about technological risks, cultural theory looks for understanding of the different positions, not in scientific analysis, but in the different premises from which opponents and proponents argue. One example of a cultural theory construction of attitudes to a risk, is the different way that old people and young people living on the same street might perceive the riskiness of slipping on ice. While to the older people it will likely be a risk they wish to avoid for fear of injury, to the children on the street it may well represent an activity of fun and excitement. Hence while living on the same street, these two groups of people belong to two different cultures when considering this particular activity (Adams, 1995).

Althaus (2005) explains that risk can be defined in different ways and offers the following definitions as used in different risk literatures:

- Objective risk refers to the difference between actual losses and expected losses.
- Real risk combines the probability and negative consequences that exist in the real world.
- Observed risk is the measurement of the combination of probability and negative consequences that is obtained by constructing a model of the real world.
- Perceived risk is a rough estimate of real risk made by an untrained member of the general public.
- Subjective risk is that experienced by an individual who is faced with uncertainty about the outcome of an event or activity.

Contained in these definitions is a distinction between risk that is defined as a reality that exists in its own right in the world (objective risk and real risk) and risk defined as a reality by virtue of a judgement made by a person or the application of some knowledge to uncertainty (observed risk, perceived risk, subjective risk). Whereas the former views risk from a realist perspective, the latter considers risk from a constructionist approach. In the next section the focus turns to the fourth of these definitions, that of risk perceptions.

3.2.4 Risk perceptions

As risk decisions are rarely made with information that can be reduced to quantifiable probabilities (Adams, 1995) risk perceptions are of fundamental importance to understanding how people might react to potential risks. Put simply, if the analysis of risk includes some notion of 'undesirable effect or event', it is important to recognise that "what people perceive as an undesirable effect, depends on their values and preferences" (Renn, 1998).

Therefore, within the social sciences, people's judgements about events, situations or activities that could lead to negative consequences are usually labelled as risk perceptions

(Renn, 2008). In general, risk perception refers to the way in which people analyse and interpret physical signals and/or information about potentially harmful events or activities and then form a judgement about seriousness, likelihood and acceptability of the event or activity.

Douglas (1985) claims that risk perceptions are a ‘subdiscipline’ of the study of risk that can be dated to Chancey Starr’s 1969 article in Science ‘Social benefit versus technological risk’, where he developed discussion about acceptability of risk to the public and showed how it varied depending, among other things, on the nature of exposure.

It is therefore the nature of modern risks that has given rise to the importance of risk perceptions in the study of risk. The ‘new’ technical risks that, according to Beck, define our society, tend not to be geographically restricted; to be complex; to have potential damages that can barely be calculated; to be mainly invisible; to produce long-lasting outcomes which are difficult to determine; and to have effects that cannot be easily reversed. Thus the characteristics of new technical risks mean that adequate analysis through probability estimates is virtually impossible (Zinn & Taylor-Gooby, 2006). These characteristics of technical risks are therefore interpreted through different cultural lenses whereby perceptions are shaped accordingly.

As noted above, traditional risk analysis represents a realist concept of risk. According to this approach, risks can be quantified, objectively and accurately, because they exist ‘out there’. The realist approach rests on a belief that experts can calculate the ‘real’ amount of risk associated with a technology. As a regulatory tool, realist risk analysis is a technocratic approach to decision-making which relies on scientific experts, and a belief that rational and objective decisions can be made about risk (Wickson, 2007). However, in many cases, perceptions of risk do not correlate with measurable probabilities of risk and therefore other factors are important in interpreting how people understand risk. The belief that risks are socially constructed therefore questions the notion that risks are ‘out there’ and points to the need to understand risk *perceptions* (Botterill & Mazur, 2004).

As Finucane and Holup (2005) point out, risk is a social construct, that cannot be considered independently of cultures and society. Cultural beliefs, values, and customs can be said to underlie risk perceptions and it is these that people may draw on unconsciously when making decisions in the face of uncertainty. Hence, groups of people with different social, economic and cultural backgrounds, perceive risks in ways that reflect their social and cultural knowledge and environment (Lofstedt & Frewer, 1998). So while the individual perception of risk may include an idea of actual damage, it is likely to be more closely connected to the risk context and associations between the risk and social or cultural factors (Renn, 1998).

Adams (1995) suggests that different cultural perspectives and corresponding risk perceptions become relevant when there is scientific uncertainty. That is, cultural biases and culturally-shaped beliefs are only relevant for understanding risk when a lack of scientific data leaves room for debate about impacts.

Psychometric and cultural theory approaches to understanding risk are constructionist in nature, rather than realist. Therefore, using these theoretical approaches, technical risk assessment is not likely to be viewed as satisfactory because it is unlikely to consider whether risks are, for example, familiar, controllable, or reversible. Further, technical risk assessment processes do not consider how individual judgements about risk acceptability are framed by beliefs about society and nature. Thus, rational risk assessment is inadequate because it lacks inclusion, or even recognition of the importance, of risk perceptions.

Finally, returning again to the technical definition of risk as Risk = Hazard x Exposure**,** the Royal Society (1983) defines 'hazard' as a situation that could lead to harm. Harm is taken to imply injury or damage, whilst exposure encompasses frequency and probability of occurrence. Uncertainty is inherent in this definition because the perception of hazards is entirely subjective. What one person finds hazardous, another may not. Risk perceptions therefore arise from the way in which individuals feel threatened by circumstance, and the opinions that individuals develop through association with the threat or hazard.

The studies presented in this thesis are therefore concerned, not with any statistical probability of the occurrence of an undesirable event, but with peoples' perceptions of risk. Where this influences behaviour and decision-making with respect to such activities as food purchasing or technology adoption, it is *perception* of risk that is important.

As Riddel (2009) states: "If the intent is to predict individual behaviour and choices over risky outcomes, then risk perceptions are superior (to expert-assessed risks), since people make decisions based on their own beliefs".

In what follows, consideration to given to the factors that have been identified as influencing perceptions of risk, drawing on sociological, cultural theory, psychological and economic approaches to investigating risk perceptions.

3.3 Factors affecting risk perceptions

3.3.1 Socio-demographics

It has been pointed out that there is a variety of socio-demographic characteristics that can influence risk perceptions, such as socio-economic factors, and differences in gender or age (Frewer, 1999). Specifically, women have generally been found to express greater perceived risk than men (Frewer, 1999). For example, in an internet survey of Finnish adults, respondents were asked to rate the scariness of six different food risks and the likelihood of being affected by that risk (Leikas *et al*, 2007). The study found that women found risks scarier and more likely to affect them personally than did men. In another study, Frewer (1999) found that members of the top two socio-economic groups tended to perceive less risk than respondents in the lower socio-economic groups. Hence, perceptions of risk were highest for the poorest group of respondents and lowest for those in the highest income groups.

3.3.2 Cultural factors

While individual characteristics may be useful in explaining differences in perceptions of risk, cultural theorists posit that there are also important cultural factors that are useful for understanding risk perceptions. Taking into account both socio-demographic characteristics and cultural context, what this means in practice is that differences in perceptions of risk may exist between different countries, and between different individuals within countries. Hence, there may be cross-cultural and national differences which mean that risk perceptions cannot be evaluated or understood outside of the social context (Frewer, 1999). As uptake and acceptance of GM technology has varied greatly between countries, and between cultural groups within societies, this is likely to be relevant to this study.

3.3.3 Attitudes to nature

The term ‘cultural theory’ is formally applied to a theory about how cultural influences can be conceptualised. The theory suggests that there are four social groupings to which people belong and that each of these groups capture a commitment to a particular way of organising society. Since the commitment to a particular group is believed to be underlain by common values, it is of relevance to the study of risk since it is also likely to lead to common fears. The fourfold typology used in cultural theory describes four different cultural biases with the horizontal axis running from a belief in human nature that is individualistic to a more collective approach, and the vertical axis representing belief in equality. In short, the typology characterises beliefs as being individualist (preference for freedom from constraints), hierarchist (supporting hierarchical social organisation), egalitarian (strong group loyalties but not supporting externally imposed rules) or fatalist (no support for organised groups or belief in individual control) (Wickson, 2007).

When applying cultural theory to an understanding of environmental risk perception, it is suggested that a fourfold typology describing four ‘myths of nature’ can be laid over the social organisation typology. The four ‘myths’ are: nature benign or robust, nature ephemeral or fragile, nature perverse/tolerant or robust within limits, and nature capricious. In the nature benign category, nature is seen as being predictable, bountiful, robust, and stable. This view encourages the exploitation of nature. Nature ephemeral is the opposite view, stating that nature is fragile, precarious and unforgiving. This position holds that once ecological stability is lost it is difficult to re-establish. The nature perverse/tolerant category refers to the view that nature is predictable and stable only up to a certain point. This encourages environmental management with caution. Capricious nature is viewed as unpredictable and essentially uncontrollable. Therefore this view suggests that prediction of impacts and planning for change are not possible (Wickson, 2007; Milton, 1991).

The implication of this aspect of cultural theory is that concerns about technological or environmental risks may not be based on possible physical impacts, but may derive from a commitment to different forms of social organisation and beliefs about nature. Therefore, in any debate about physical risks, cultural theory suggests that people will argue from different premises or perspectives, and their corresponding attitudes to nature will influence their perceptions of environmental risks, the extent to which impacts can be predicted and planned for and the implications of those impacts.

3.3.4 Role of the media

It has been claimed that the media has a role to play in influencing the way people form risk perceptions since people’s experience of hazards tends to come from the media and its presentation of threats (Roth *et al*, 1998). It is even claimed that the media can cause people to misjudge risks (Slovic *et al*, 2000). Nevertheless the media is also recognised as being important as a means of raising awareness of risk issues of which people might otherwise have no knowledge (Bocker & Hanf, 2000).

It is thought therefore that there are two ways in which the media can influence perceptions of risk. In some cases the media is accused of creating, or at least, amplifying risks, in others it is assumed to be merely an informational vehicle. Thus the role of the media may be to have either a direct or indirect effect on peoples’ risk perceptions and attitudes. The former involves “dramatising the reality” (Vilella-Vila & Costa-Font, 2008) thereby directly influencing and enhancing peoples' negative perceptions of risk. The media may however be more passive, and simply report the ongoing debate. The influence here derives not from dramatisation but continuing the emphasis and focus, that is, keeping the spotlight on the debate.

The idea that the media may be guilty of 'amplifying' risks is described by the theoretical framework known as the social amplification of risk. In this framework the media is accused of bias and sensationalism (Kunreuther & Slovic, 2001) thereby feeding the growth of 'stigma' attached to new technologies. Some commentators have argued that modern technology has spawned a new type of stigma, which represents modern-day concerns about ecological and human health risks arising from technological developments (Flynn *et al*, 2001). The role of the media in the growth of such stigma is believed to be one of interaction with peoples' perceptions, that then leads to disruptions, for example in the commercialisation of new technologies, that are actually more problematic than any threats that might have arisen from the new products (Kunreuther & Slovic, 2001). In this way, it is argued, the media has an important role in influencing perceptions of risk.

Under the social amplification of risk framework, perceptions of risk are believed to be influenced by psychological and other factors via impetus from communication channels, including formal channels such as the media (Masuda & Garvin, 2006).

There is evidence to support the theory that receiving information increases uncertainty about risky technologies, and what is relevant here is that most people receive information through the media. For example, when asked about sources of information about a proposed nuclear waste facility in the USA, the majority of respondents indicated that they got information from the media, specifically through the television, radio and newspapers (Riddel, 2009). They also found that people who had received more information expressed greater uncertainty about the risks associated with nuclear waste. This demonstrates the indirect way in which the media may apparently influence perceptions of risk.

Whichever role is assigned to the media it is reasonable to expect that peoples' risk perceptions are influenced by both the type and number of stories featured. So while the media may not determine how people perceive risks in a linear fashion, over time it may be a significant source of information that influences perceptions (Powell *et al*, 2007).

3.3.5 Initial impressions

The importance of initial impressions, or those attitudes and opinions that are formed first, is another factor that has been claimed to influence risk perceptions. As Slovic (2000) points out, once formed, initial impressions affect the way that any new information is interpreted. New evidence is likely to be taken as reliable and accurate if it is consistent with the initial belief, but contradictory evidence may be considered to be incorrect and misleading. Therefore, initial views are unlikely to change just because new information is presented or fresh guarantees of safety are put forward. However, it should also be noted here that the importance of initial views was questioned in a study by Maruyama and Kikuchi (2004). They found that new information was more important than prior information when people were making willingness to pay choices. They concluded that participants did adapt their prior risk perceptions when new risk information was presented to them.

3.3.6 Trust

There is an assumption by some writers that trust is the determining factor in the perception and acceptability of risks. Why are some regulatory agencies or information sources not trusted? Put simply, people trust or distrust others based on an expectation of their trustworthiness (James & Marks, 2008). Expectations of trustworthiness encompass two components - perception of the motives, incentives, or goodwill of those in whom trust is placed, and perception of their competence or dependability. Although there are obvious similarities, there are also differences between trust in personal relationships and social trust. The latter, significantly, incorporates issues of power and control, such that the person trusting is in a subordinate position relative to those in whom trust is placed. In addition, social trust involves a degree of impersonality not associated with the issue of trust in personal, face-to-face relationships (Cvetkovitch & Lofstedt, 1999). It is important to note also that it is widely recognised that once trust is lost it is difficult to regain (Slovic, 1999).

The level of trust that people have in institutions to regulate or control technological risks is considered to be an important factor in the acceptability of risks (Poortinga & Pidgeon, 2005). Thus, individuals respond positively or negatively to risk-related problems in line with their trust in governing bodies (Guehlstorf, 2008). That is, the extent to which people trust risk managers determines the level of perceived risk, and consequently the acceptability of particular activities or technologies. This is known as the '*causal chain'* model of trust (figure 3.2) and is the most common interpretation of the relationship between trust, risk perception, and acceptability of a technology or activity.

Figure 3.2: The causal model of trust

Source: Poortinga & Pidgeon, 2005

It is not only trust in governing institutions and regulatory authorities, however, that is important to the formation of risk perceptions. Risk communication messages may fail to lead to the required response because it is not only the content of the message that is important but also the bodies or individuals providing the messages. Thus, trust in information source is also important to risk perceptions (Cvetkovich & Lofstedt, 1999).

In a study investigating risk perceptions and the intention to purchase chicken (or not), Lobb *et al* (2007) found there was an interaction between trust and risk perception, and specifically that trust in different information sources determined levels of perceived risk. People who expressed greater levels of trust in information provided by the media and 'independent sources' had a higher level of perceived risk regarding eating chicken, whilst those with trust in public authorities expressed lower levels of perceived risk. Put another way, and in common with other studies, having little or no trust in public authorities means that perceived (food) risks are greater. Bocker and Hanf (2000) also considered the importance of trust. They assumed that in the case of food safety, a number of issues affect purchase decisions, including perceived differences in the reliability of supplier types or trust in the reliability of individual suppliers. Ter Huurne and Gutteling (2008) also found that trust (in government and in companies using chemicals), among other things, affected risk perceptions. Risk perceptions were measured by asking respondents to rate perceived risks from hazardous substances on a five-point scale from 'not dangerous at all' to 'extremely dangerous'. In a study conducted in Sweden in 1996 four 'trust dimensions' were investigated to see if they were related to perceptions of risk. The four trust dimension scales were: trust in corporations; trust in politicians; perceived social harmony (is society relatively harmonious or is it full of conflict?); and perceived general honesty (are people in general honest and to be trusted?). Perceptions of general and personal risk associated with 35 hazards (including genetic engineering, nuclear power, chemical waste, alcohol and so on) were measured on a seven-point scale. Of the four trust dimensions, trust in corporations and social harmony correlated consistently with perceived risk (Sjoberg, 1999).

These examples demonstrate the existence of a connection between the trust that people feel towards a range of organisations and information sources, and their perceptions of risk.

3.3.7 Psychometric paradigm dimensions of risk

Moving on from the societal and cultural theories about how people form risk perceptions, the psychological approach rests on the understanding that people form risk perceptions based on aspects that are cognitive, affective and behavioural. Similarly to the social and cultural theories, however, psychometric research challenges the realist notion of risk by suggesting that there are characteristics (beyond likelihood and magnitude) that influence how risks are perceived (Wickson, 2007).

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In many studies of risk perceptions a psychometric approach is adopted. The approach originated in cognitive psychology and was developed by Paul Slovic and colleagues (Hansen *et al*, 2003). Within this theory, Slovic (2000) points out that the majority of people rely on what is essentially an intuitive risk judgement, and therefore do not use a process of formal risk assessment to evaluate hazards in the way that scientific personnel or technology specialists might. Hence, people's understanding of riskiness is about much more than risk statistics. Overall, the focus of Slovic's work is psychological, and forms the basis of one of the most important areas of research into risk perceptions, that of the psychometric paradigm.

The purpose of the psychometric paradigm is to produce quantitative representations of risk perceptions using scaling methods and multivariate analysis (Slovic *et al*, 1984). Application of the psychometric paradigm approach involves providing respondents with lists of hazardous activities and technologies and asking them to rate the riskiness of them. In addition, people are asked to provide qualitative judgements about risk characteristics such as voluntariness and controllability. In what follows, these characteristics, or dimensions, of risk are considered further.

The psychometric paradigm contains a number of dimensions of risk that are said to contribute to people's overall risk perception of a particular activity or technology. Various authors have listed the dimensions of risk considered to be relevant to peoples' risk perceptions. These cover issues such as whether exposure to the risk is voluntary, whether the risks presented are familiar, what the potential is for catastrophic consequences, to what extent people have knowledge of the consequences, the immediacy of impacts, and equity of impacts (Fischhoff *et al*, 2000b; Wilson & Crouch, 2001; Slovic, 2000). Many of the risk dimensions have been found to be correlated with each other. Thus hazards that are judged to be voluntary also tend to be considered to be well-known and controllable. Correspondingly, hazards judged to threaten future generations also tend to be judged to have the potential to be catastrophic (Slovic *et al*, 1984). Through a process of factor analysis it has been shown that these qualitative judgements can be condensed into a smaller set of characteristics. These can be labelled 'dread risk' and 'knowledge' (Slovic, 2000) (figure 3.3). Dread risk is defined at its top end by perceived lack of control, dread, catastrophic potential, fatal consequences and the inequitable distribution of risks and benefits. Knowledge is defined at its top end by hazards considered to be unobservable, unknown, new, and where any harm that may arise is likely to occur at a later date. Research has shown that peoples' risk perceptions are related to the position of a hazard within this factor space, and that the dread risk factor is most important in defining where any particular hazard is placed. Fischoff *et al* (2000) found that the knowledge dimension was useful in distinguishing between types of technologies, with the high end characterised by new, involuntary, poorly-known activities, often with delayed consequences. What can be seen in figure 3.3 is the placement of GM animals and GM plants further right than any of the other risks, towards unknown risk. However, they do not feature so highly up the dread risk axis (in-depth consideration of perceived risks of GM technology follows in section 3.4).

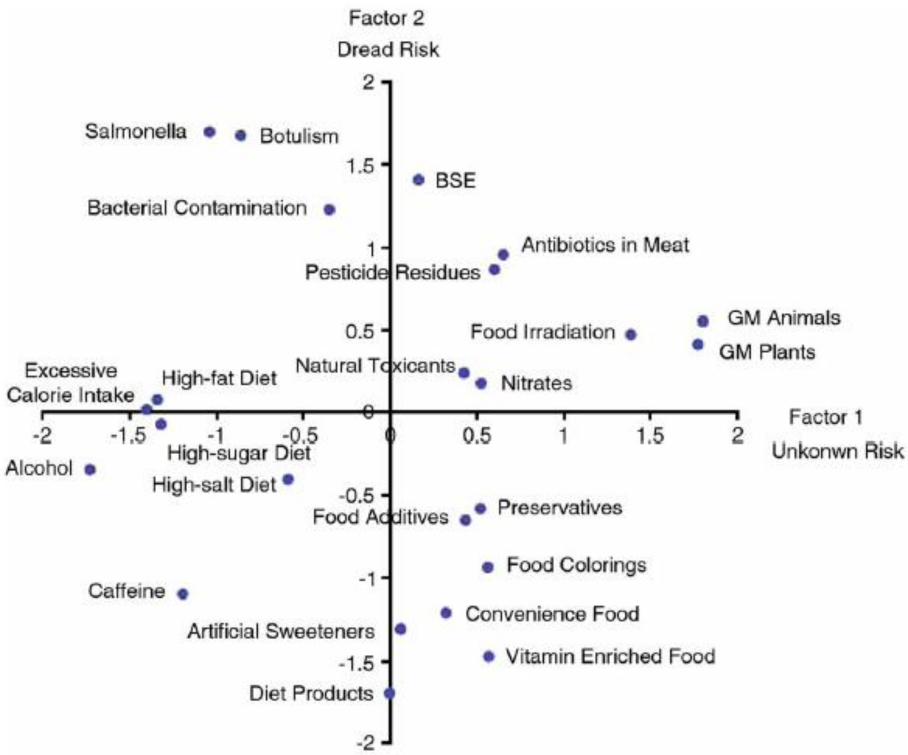

Figure 3.3 Matrix of perceived food hazards

Source: Siegrist *et al*, 2006

The implications of the psychometric paradigm dimensions of risk can be seen in circumstances where people feel they have little personal control over their exposure to a particular hazard, and where the institutions that have responsibility for protecting the public indicate that there is uncertainty associated with risk estimates. In these cases, the hazard may appear to be out of control, and this is associated with a perception of serious risk (Miles & Frewer, 2003). It will be shown below that a number of these dimensions of risk appear to be highly relevant to the issue of risk perceptions associated with GM food.

3.3.8 Uncertainty

As noted above, among the psychometric paradigm dimensions of risk are those relating to knowledge and uncertainty about a technology. The latter is considered in greater detail in what follows. When considering the psychometric paradigm, it has been hypothesised that the components of the 'unknown' risk factor are directly related to uncertainty about the frequency of occurrence of the risk 'event'. Further, many of the components of the dread factor are hypothesised to be directly related to uncertainty regarding the severity of the risk (Slavin *et al*, 2008). If this is the case it suggests that uncertainty is among the most important issues for explaining perception of risks.

Uncertainty exists when someone believes there is a lack of knowledge. A conceptual framework for understanding how individuals view uncertainty suggests two types: external and internal. In the first, uncertainty exists in the external world. In this case it could relate to uncertainty in scientific knowledge about a risk. Internal uncertainty is when a person feels that they are uncertain, for example, because s/he feels uninformed about a risk. Thus the lack of knowledge underlying uncertainty can be personal, someone else's, 'out there' in the world, or a combination of these. Uncertainty therefore arises when there are gaps either in one's own knowledge or in knowledge in general (Powell *et al* 2007).

In practical terms someone's internal uncertainty about a risk issue could be realised as follows. Internal uncertainty about environmental contaminants, for example, may exist because they cannot be seen, smelt or touched, because in many cases health problems may not show up for years, giving them an intangibility, or because information is not provided by authorities.

Beyond this internal / external definition of uncertainty, other classifications have identified various types of uncertainty. These include: Measurement uncertainty, temporal uncertainty (uncertainty in past and/or future states), structural uncertainty (due to the complexity of the situation being evaluated or modelled), translational uncertainty (problems explaining uncertain results), uncertainty due to expert disagreement, and limitations of data (Miles & Frewer, 2003).

Further, Wickson (2007) argues that new technologies such as genetic engineering have lead to new kinds of uncertainty that become relevant when trying to assess environmental impacts. These new types of uncertainty are referred to as ‘ambiguity’, ‘indeterminacy’ and ‘ignorance’. ‘Ambiguity’ arises when contradictory information is available from different sources and when there are various underlying assumptions and values framing the topic differently. ‘Indeterminacy’ is uncertainty that exists when there is complexity involved in trying to predict outcomes of interactions between and within social and natural systems. ‘Ignorance’ is the uncertainty that exists when people are unable to consider outcomes that are outside of current understanding, or the “things we don’t know we don’t know”.

From a number of focus groups were derived 10 statements relating to how members of the public conceptualised uncertainty associated with potential food safety hazards (Frewer *et al*, 2002). Interestingly, the statements can all be classified as referring to external sources of uncertainty and are as follows:

- The government lacks definite knowledge about the topic
- It is not possible for scientists to have all the answers
- The government’s statement is based on conflicting information
- The information provided is the best available at present, but things may change in the future
- The government is unsure about the extent of the problem
- Scientists disagree with each other on the subject
- The government is unsure whether there is a problem or not
- More scientific work needs to be done on the topic
- The government is withholding information from the public
- There really is a major food safety problem

One important point regarding uncertainty is that it is generally not the same as no knowledge at all (van Asselt & Vos, 2008). In many cases of new scientific discoveries or technological developments, experts may hold some knowledge or information about uncertainties. For example, there may be accepted wisdom about sources of uncertainty and about which uncertainties are important.

If perceived risk is related to uncertainty (in whatever form) it might be expected that decreasing uncertainty, in terms of greater knowledge or experience, would decrease or remove negative perceptions. However, the idea that less uncertainty equals lower perception of risk equals greater acceptance of new technologies is formally challenged by the theory proposed by MacKenzie (1990), known as the ‘certainty trough’.

The Certainty Trough describes the relationship between a new technology and the certainty about what it can do or how it should be used (University of Illinois, no date). The line in figure 3.4 represents the amount of uncertainty about the technology. It might be reasonable to assume that as people become more familiar with, and knowledgeable about, a new technology that the level of uncertainty would decrease. In this case the figure would show a straight line running from lower left to upper right. MacKenzie proposed a less straightforward relationship such that there are three ‘phases’ in the relationship between familiarity with a new technology and certainty about that technology.

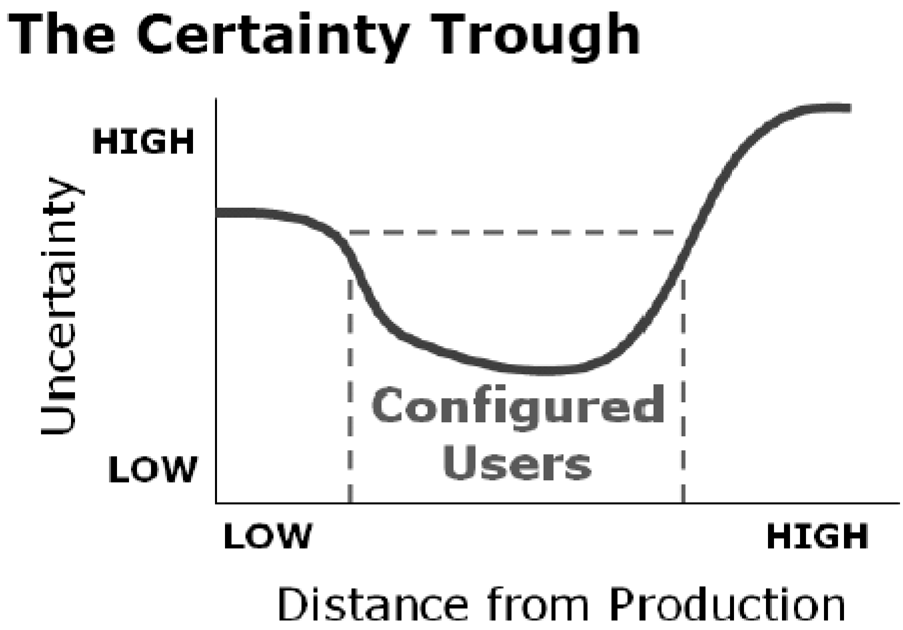

Figure 3.4 Certainty Trough

Source: University of Illinois, no date

Distance from the production of the technology equates to the extent to which people know about it. The greatest distance from the technology corresponds with the highest level of uncertainty. However, the smallest distance from the technology, meaning here the greatest knowledge of and familiarity with the technology, does not correspond with the lowest level of uncertainty.

Mackenzie claimed that the people with the best knowledge of the technology are most likely to be aware of problems with it or ways in which it could be improved (Shaw, 2009). Thus they have more uncertainty about the technology than those who have some familiarity with it and are users of it.

The implication of this theory for addressing the issue of uncertainty, may be that proponents of the technology may have an interest in ensuring that users have a certain level of information so that they move from the right of the graph to the middle but that effectively too much information may not have the desired effect.

A further theory about the issue of uncertainty is that actually some people may be unconcerned about it. This is demonstrated by some examples of uncertainty scenarios, proposed by Powell *et al* (2007). Consider for example numbers two, three, five and eight in the following list. These suggest that there are occasions when people are aware of their own uncertainty relating to a risk issue but do not care, are resigned, or do not consider it to be important.

- *I don't know anything about X; I will leave it to experts to tell me what I need to know.*
- *I don't know about X; that's okay because it isn't that important or relevant to me.*
- *I don't know much about X, and I don't want to know any more.*
- *I don't know much about X and I want (or need) to know more, so I intend to learn more*
- *about it.*
- *I don't know about X; no one else knows much (or anything definitive) about X, and*
- *there's not much we can do about it.*
- *I don't know about X, but my friends and family know quite a bit about it; I'd better find*
- *out more about it, or I might be left out.*
- *I don't know about X and I don't have the skills to find out; therefore, I can't really learn*
- *more about it until I acquire these skills.*
- *I don't know about X, and I can't get the information so I can't really learn more about*
- *it until the information becomes more accessible.*

It is apparent that uncertainty may take many forms. Nevertheless, as described in the section above relating to the psychometric paradigm, uncertainty (in whatever form) may be an important influence on perceptions of risk.

3.3.9 Associated benefits or the risk/benefit relationship

An important point that emerges from the literature describing factors that can influence risk perceptions, is that understanding how people perceive associated benefits is crucial, since the two are inextricably linked (Frewer, 1999). Risks and benefits will tend to be positively correlated in the environment (Finucane *et al*, 2000). However, as concepts in decision-making, risk and benefit are distinct from each other. What is interesting about these risk and benefit concepts is that, while being positively correlated in the environment, they are generally negatively correlated in peoples' minds, that is, when what is being considered is risk and benefit *perceptions*. Thus it has been demonstrated that the relationship between risks and benefits is an inverse one - the greater the perceived benefit, the lesser the perceived risk, and vice versa (Alhakami & Slovic, 1994). For example, Fischoff *et al* (2000) found that participants believed that more risk could be tolerated if activities offered more benefit.

One reason for this is thought to be related to the way that people make decisions based on affect, as well as cognition. Thus if people have a positive emotional response to a certain activity or technology (put simply, they like it), then their perceptions of risk will be low and perceptions of benefit high (Finucane *et al*, 2000). As an example, people might get a positive gain (enjoyment) from taking part in a risky activity such as skiing or using a risky technology such as headphones and an MP3 player, thus are likely to tolerate the risks associated with these activities and technologies.

The relationship between perceived risk and perceived benefit is considered in greater detail in section 3.4 focused specifically on risk perceptions and GM technology.

3.3.10 The way the question is posed

An additional factor thought to influence the risk perceptions expressed by individuals, relates to the way in which a survey question is framed or posed. For example, Wilson and Crouch (2001) found that when respondents were presented with a question giving them a choice between gains (number of people saved) their answers showed them to have a different attitude towards risk than when the choice was between losses (number of deaths). The issue of question format is one that has been given considerable coverage in the field of environmental economics, in particular in terms of the variation in answers to willingness to pay and willingness to accept questions. This issue is pertinent to chapter four that follows.

3.3.11 Conclusions

To conclude, there is a number of factors thought to influence how people form risk perceptions. The factors that have been considered here are socio-demographic factors, cultural factors, attitudes to nature, the role of the media, initial impressions, trust in different sources of information and organisations, psychometric paradigm dimensions of risk, uncertainty, associated benefits, and the way the question is posed. However, these are not all. Additional factors are discussed below. In sections 3.4 and 3.5, examples are given of studies that have found evidence of these and other factors influencing risk perceptions. The sections relate first to studies investigating risk specifically in relation to risk perceptions of GM food, and second to studies investigating risk perception in relation to farmer decision-making and technology adoption.

3.4 Factors influencing risk perceptions of GM technology

In the paragraphs that follow, numerous studies are reviewed. These are studies that have specifically investigated attitudes towards GM food, and between them, their findings can be said to support various aspects of the theoretical claims about influences on risk perceptions. Of the factors theorised above to influence perceptions of risk, those most pertinent to the GM debate include: A number of socio-demographic variables, the issue of trust, a number of the psychometric paradigm dimensions of risk, such as voluntariness of exposure, knowledge and unpredictability of impacts, and the relationship between risks and benefits. In addition, a number of topic specific issues have been found by previous studies to be relevant, particularly, environmental attitudes and attitudes towards new technology in general.

3.4.1 Socio-demographics

In line with the theory about factors that may influence risk perceptions, a number of studies that have investigated attitudes to GM food have highlighted the importance of a range of socio-demographic variables. For example, Gaskell *et al* (2003) found that a typical supporter of GM was likely to be male and well educated. As noted above, it is common for men to be found to have a lower perception of risks than women.

Demographic characteristics were also found to have some relation to the levels of acceptance of GM products when respondents were asked to evaluate different items in Holland (Hamstra & Smink, 1996). Further, in a study with US consumers, Moon and Balasubramanian (2001) found that perception of health risks of GM products differed significantly by gender and the level of education but not age. Once again, males were less likely to perceive health risks from GM foods than females. Again, similar to the Gaskell *et al* study referred to above, the higher the level of education, the less likely people were to perceive health risks related to GM foods.

Again in common with Gaskell *et al*, Subrahmanyan and Cheng (2000) reported that, in Singapore, women were more concerned about the ethical and health aspects of GM food than men, and that postgraduates were least concerned about health and ethics and more likely to buy GM products where benefit was shown. They also investigated the impact of a range of other socio-demographic characteristics and found that married respondents were less concerned about health issues than single people. In addition, people with children under 15 were less concerned about health issues and more likely to buy GM food if benefits were offered by the food (they do not specify what benefits). Further, they found that Hindus were more likely to buy GM food where there were benefits, and that vegetarians were more concerned about the ethics of GM food than non-vegetarians.

In a survey carried out in France and Germany in 2000, and UK and USA in 2001, young people were shown to be less concerned about GM food than the elderly, and people on low incomes were more wary of GM food than those more wealthy (Bonny, 2003). Contrary to this latter finding, Siegrist (2003) found that socio-economic status did not have an influence on beliefs in risks and benefits GM technology in food.

There is clearly a wide range of studies that have considered the importance of socio-demographic variables in influencing perceptions of risk, and thus acceptability of GM foods. However, evidence is not consistent, suggesting that socio-demographic variables alone are not sufficient to explain risk perceptions.

3.4.2 Cultural factors

A range of cultural factors has been identified as having some impact on the perceptions of risks relating to GM foods. Indeed, Herrick (2005) claims that risk is highly contingent upon cultural factors. Overall, the study by Herrick takes a geographical perspective to understanding the ‘risk discourse’ relating to GM. The author claims that perceptions of risk associated with GM food are formalised by policymakers through labelling laws – something that is dealt with very differently in the EU and the US. This, the author claims, demonstrates the extent to which risk perceptions relating to GM food are culturally different. Of relevance here is the fact that people in different countries differ in their acceptance of GM food.

Perceptions of, and attitudes towards, GM food were investigated through data from telephone surveys in Switzerland. Political beliefs were found to significantly influence perceptions of GM technology. Specifically, left-wing people perceived less benefits and more risks than right-wing people (Siegrist, 2003).

It has been suggested that acceptance of GM food within a country is negatively related to the wealth of that country (Siegrist, 2003). In 17 European countries (EU15 plus Norway and Switzerland) strong negative correlations were found between GNP per capita and perceived benefit, and acceptability of the technology. Weaker positive correlations were demonstrated between GNP per capita and perceived risk of GM food (Siegrist, 2001). Siegrist further discussed the fact that peoples' worldviews determine whether they agree with industry claims that there are no risks, or whether they have concerns about risks. Overall, Siegrist concluded that cultural values associated with food may be important in determining perception of GM food in any given country.

A practical example of the implications of different cultural framing of the risk associated with GM food and crops is revealed by the different regulatory positions in the US and EU. Authorisation for their commercial use has been obtained more readily in the USA than in the EU, where applicants have faced long regulatory delays and requests for more scientific information (Levidow *et al*, 2000).

Aerni (2005) commented that risk perception is a social and cultural construct that may differ between societies that have different political, cultural and economic conditions. The author claimed that this is realised in practical terms through stakeholder interests and the prevailing public perception, which help to shape political decisions about the potential adoption of technologies such as GM crops.

As with the studies investigating socio-demographic characteristics and perceptions of risk, it is clear that cultural factors are linked to risk perceptions, but drawing consistent conclusions is problematic.

3.4.3 Environmental values and attitudes to nature

Further issues that have been shown to be relevant to risk perceptions when related specifically to GM foods, are environmental values and attitudes to nature. For example, Grunert (2001) carried out research into consumer reactions to GM food, covering Denmark, UK, Italy, Finland, Germany, Sweden and Norway. A GM yoghurt was presented which was fat free, creamy and without additives. From the results, the author concluded that negative consumer attitudes to GM food are embedded in general attitudes to nature. In the USA, Charles (2001) found that concerns about GM crops were based on objections to the manipulation of nature. Opponents were concerned about cross-pollination from GM crops to related wild plants, and about wild plants becoming more 'weedy'. Gaskell *et al* (2003) reported in the Eurobarometer survey of EU citizens, that the majority of Europeans did not support GM foods and crops and were concerned about the fragility of nature and about the impact of human actions and technology on nature. If the 'four myths of nature' fourfold typology is applied to these results it suggests that 'nature ephemeral' is the one subscribed to when forming perceptions about the risks of GM technology. Thus the cultural view of nature relevant to consideration of risk perceptions is that nature is fragile, precarious and unforgiving, and stability once lost, may be difficult to re-establish.

Research carried out in UK, France, Germany and Spain using focus groups found that strong expressions of concern about GM food were centred on the balance of nature and whether certain GM products could be judged to be environmentally friendly or not (Lemkow, 1993). In a study in Holland about GM technology, background attitudes towards nature were found to have some relation to the levels of product acceptance (Hamstra & Smink, 1996). In another study, Siegrist (2003) found that concern about environmental issues and environmental attitudes influenced perceptions of GM food risks, in a study carried out in Switzerland. Finally, in another study, perceptions of unnaturalness or tampering with nature, were found to be one of the most important determinants of public reactions to GM food (Lofstedt & Frewer, 1998).

Overall, the studies reviewed here serve to illustrate the importance of environmental values and attitudes towards nature in shaping perceptions of risk and attitudes towards GM food. In the next section, a second, topic-specific issue is addressed, that of attitudes to technology.

3.4.4 Attitudes to technology

In addition to attitudes to the environment considered above, general attitudes to technology have been found to be relevant to perceptions of risk of GM food. For example, as reported above, Grunert (2001) carried out research into consumer attitudes to GM food in Denmark, UK, Italy, Finland, Germany, Sweden and Norway. From the results, the author concluded that negative consumer attitudes to GM food are embedded in general attitudes to technology. In a study carried out in Holland, background attitudes towards technology were found to have some relation to the levels of product acceptance of GM foods (Hamstra & Smink, 1996). In addition, Siegrist (2003) found that general attitudes towards technology significantly influenced perceptions of GM food. Also, Gaskell *et al* (2003) found that a number of characteristics such as value orientations and beliefs about technology and progress influenced beliefs about GM food.

3.4.5 Role of the media

In line with the discussion in section 3.3.4, many commentators have claimed that the media was at least in part responsible for the rejection of GM foods in some countries, because of its role in presenting GM technology as offering substantial but unknown risks. For example, results from a study conducted in Spain and the UK revealed that public perceptions of risk relating to GM food increased in line with news reporting (Vilella-Vila & Costa-Font, 2008). Press coverage of GM technology in the UK and Spain focused on risks and potential hazards to public health, framing GM food as a highly controversial issue. Findings pointed to an association between this negatively-biased news and a pervasive negative public attitude towards the technology. Further, attitudes towards journalism were found to correlate with risk perceptions of GM food.

Aerni (2005) also claimed that the media had a role in representing and influencing public perceptions which then shaped decisions about adoption of GM technology. Specifically, the author claimed that an individual's perceptions of the risks and benefits of a new technology such GM food are shaped by the information they receive. In the case of biotechnology most people must rely on the mass media for their information, thus the media has a significant role to play in the formation of risk perceptions.

The media is only likely to be an important influence on peoples' perceptions of risk of GM technology if it is a trusted source of information. The issue of trust in influencing perceptions of risk of GM technology is considered next.

3.4.6 Trust

Trust in risk managers is known to be a key factor in public perception and acceptance of new technologies, such as GM. The term risk managers is defined broadly as organisations responsible for the development and control of biotechnology, including industry, universities, and governments, that is, not just those regulatory authorities with direct responsibility for public risk management.

Most people lack extensive knowledge of the technological details of genetic engineering (Siegrist, 2000). One way people make decisions about new technology when they lack knowledge is by placing social trust in others so as to aid their own risk assessment and risk management decisions. So trust in regulations, companies and scientists is important for acceptability of the technology. If people have trust in relevant regulatory, commercial and research institutions they are more likely to have a positive attitude towards the technology (Siegrist, 2000).

It is thought that the public believes that organisations with responsibility for developing, using and regulating GM technology incorporate two types of bias when communicating about the risks and benefits of GM (James & Marks, 2008). First, there is believed to be a reporting bias, which may understate risks and overstate benefits. Second, it is expected that there is likely to be a knowledge bias, which means that as communicators are unable to foresee all eventualities, the knowledge they impart is unlikely to be sufficient. If a significant reporting bias or knowledge bias is suspected, the public are likely to distrust those institutions, expecting that the bias is likely to be connected to behaviour that is either dishonourable (deliberately misleading) or incompetent. Ultimately, if the public distrusts risks managers they are unlikely to accept the technology, even if told it is safe.

Thus, it has been claimed that public trust in GM technology, and thereby their acceptance of it, may be undermined if people believe that government is promoting technology that is considered to increase corporate control of food systems, to benefit agribusiness and reduce consumer choice (Salleh, 2008). Clearly, for this to be the case, individuals must have concerns about corporate control of the food chain and about the role and power of agribusiness.

Siegrist (2000) suggests that trust in the biotechnology industry may be improved if the technology is framed in a way that reflects the publics' values. However, given that many claims have been made that there are environmental benefits from the use of GM technology, with little apparent success at swaying sceptics, it is difficult to see how this would arise. It seems more plausible to argue that the 'positive' messages need to come from trusted sources if they are going to influence either consumers or producers, thus it is the source that is of primary significance, rather than the content of the message itself.

A number of studies have addressed the issue of trust as an influence on people's perception of the risks of GM food. It has been found that GM food is indeed a subject where the public has relatively little trust in the competence of government to regulate the technology (Walls *et al*, 2005).

Further. trust in organisations doing GM research or using GM products has been found to be the most important factor influencing perception of GM technology (Siegrist, 2000) and to have an impact on both perceived risk and perceived benefit. As acceptance of GM products is determined directly by perceived risk and benefit, trust has an indirect impact on acceptance, as shown diagrammatically in figure 3.5. This is an extension of figure 3.2.

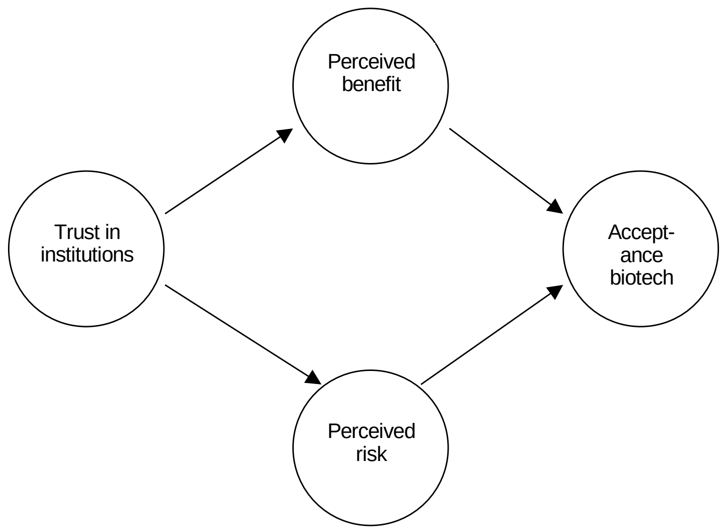

Figure 3.5: Model of acceptance of gene technology

Source: Siegrist, 2000

In the USA, Charles (2001) found that opponents of GM technology questioned the government's ability to ensure that GM foods would be safe to eat. In another study Toni and von Braun (2001) reported on a Citizens' Jury held in Brazil. During the two day 'trial' the Jury decided, among other things, that there would not be clear and positive caution in, transparency of, or participation in, the analysis and monitoring of GM field trials and commercialisation. The Jury also believed that accessibility to information about GM technology would not be positive, and that consumers and farmers would not be able to choose whether to embrace the technology or not. All of these issues are related to the issue of trust in those providing information, developing the technology and overseeing the regulation and monitoring of the technology. In research carried out in UK, France, Germany and Spain, concerns were expressed about the reliability and competence of those in charge of research into GM technology, suggesting a lack of trust (Lemkow, 1993). In addition, Siegrist (2003) found that trust in public authorities and regulators was one factor that influenced perceptions of GM food risks.

As trust has been found to be related to perceptions of GM food risks, there is merit in considering what, in turn, may influence trust. James and Marks (2008) found a correlation between the timing of an increase in negative media coverage of biotechnology in the UK, and a decline in trust of UK risk managers. Correspondingly, an increase in trust was related to a decline in the number of negative media reports, suggesting that the media may influence the extent to which people trust certain bodies. Of the people who were found to lack trust in biotechnology risk managers, some were uncertain about trusting any source of biotechnology information, while others had a distrust of risk managers but were willing to trust other sources of biotechnology information. Others still did not trust any source of biotechnology information (James & Marks, 2008). Additionally, knowledge of science has been found to be positively correlated with trust (James & Marks, 2008).

Trust is therefore a complicated issue, encompassing issues of communication bias (knowledge and reporting) and relating to both organisations and information sources. It can be indirectly related to acceptance of GM technology through its impact on the perceived risks and benefits.

3.4.7 Psychometric paradigm dimensions of risk

A number of the psychometric paradigm dimensions of risk are relevant when considering the nature of GM technology and peoples' perceptions of risk. For example, it can be argued that exposure to the potential risks has been almost entirely involuntary, and this is expected to increase perceived riskiness. Two factors are important here. First, early GM products introduced into Europe did not initially have to be labelled, and second, there was no opportunity to influence the location of GM field trials (in the UK). Hence in both of these instances potential exposure was involuntary.

Importantly, the specific risks are largely undefined, and encompass potential unforeseen consequences at a genetic level, both suggesting a high degree of uncertainty, which in turn can be expected to lead to high levels of perceived risk. The scientific community is equally unsure of the long-term consequences of exposure to GM products (see for example, GM Science Review Panel, 2003). Opponents perceive many of the risks to be unknown, unknowable, long-term, and potentially uncontrollable. The extent of uncertainty relating to the risks of GM technology has led to a sense among opponents that the risks will be potentially catastrophic. Finally, there is a large degree of dread associated with the perceived risks of GM food. The strength of opposition is perhaps hardly surprising considering that the perceived risks of GM food are of this nature.

The literature reviewed below presents findings from studies that have addressed some of the psychometric paradigm dimensions of risk as they relate to GM food. For example, research was carried out in the UK, France, Germany and Spain using focus groups

(Lemkow, 1993). In the focus groups it was repeatedly stated by participants that there is insufficient knowledge about the long-term effects of GM crops on the environment. Other doubts that were raised were that certain products, such as ht crops with apparent economic and production benefits, might have negative and unpredictable health effects. Groups in Germany, France and the UK also expressed concerns about the unpredictability of long-term impacts.

Grove-White *et al* (1997) reported work undertaken in 1996 and 1997 involving nine focus groups in Lancaster and London. The study presented participants with six products containing GM ingredients. Food safety issues were firmly fixed in peoples' minds as being long-term in nature and difficult to identify. The development of GM foods was seen as lying outside peoples' control, with little scope for public choice and intervention.

Results from a study investigating perceptions of risk of GM food revealed that respondents felt that GM food had unknown consequences, posed risks to future generations and had unfairly distributed risks (Poortinga & Pidgeon, 2003). People also felt unable to control risks to themselves and did not feel well informed about GM food. However, respondents disagreed with the statement that the idea of GM food filled them with dread.

In a two way matrix of food hazards derived from a postal survey with 448 Swiss residents, Siegrist *et al* (2006) showed that GM plants and GM animals featured high on the axis 'unknown risk'. This axis was highly correlated with immediacy of effect, knowledge of persons exposed about the risks, knowledge of scientists about the risks, and newness of the hazard. GM plants and GM animals featured above zero on the 'dread risk' axis. This second component was associated with voluntariness, harm for health, people's worries, and probability of health damage. The matrix (reproduced in figure 3.1) demonstrates how the risk dimensions may be relevant to understanding people's perception of risk relating to GM food.

The studies reviewed above appear to show that there are certain psychometric paradigm dimensions of risk that are indeed relevant to understanding people's perceptions of the riskiness of GM food.

3.4.8 Relationship between risks and benefits

As noted above, it has been claimed that risks and benefits generally tend to be negatively related in peoples' minds (Finucane *et al*, 2000). For many hazards, the greater the perceived benefit, the lower the perceived risk and *vice versa* (see for example, Alhakami & Slovic, 1994; Brown & Ping, 2003). If this relationship applies to GM technology, then producing GM foods that provide positive utility for consumers should mean that they perceive the risks to be low.

Accordingly it has been claimed by many authors that acceptance of GM technology is low when perception of benefits is low and perception of risks high (Spetsidis & Schamel, 2002; Bredahl *et al*, 1998; Kuznesof & Ritson, 1996; Hoban, 1998). Specifically, perception of risk is high, and hence acceptance of the technology low, when the only benefits are perceived to be agricultural benefits or benefits for other agents along the food production chain (Olubobokun & Phillips, 2004; Kuznesof & Ritson, 1996; Hamstra & Smink, 1996), and when the technology is perceived to be risky for health (Spetsidis & Schamel, 2002). Conversely, it has been claimed that the technology may be more acceptable when people believe its use can reduce chemical use in production (Olubobokun & Phillips, 2004; Bredahl *et al*, 1998; Kuznesof & Ritson, 1996; Hoban, 1998; Gaskell *et al*, 2003). It has been shown that GM technology may also be more acceptable if there is a perception of general environmental benefit (Bredahl *et al*, 1998; Gaskell *et al*, 2003), if the technology can offer nutritional benefits (Olubobokun & Phillips, 2004; Bredahl *et al*, 1998; Mucci & Hough, 2004) or increase shelf life (Olubobokun & Phillips, 2004), and especially if the technology offers health benefits (Spetsidis & Schamel, 2002; Bredahl *et al*, 1998; Kuznesof & Ritson, 1996; Hamstra & Smink, 1996; Mucci & Hough, 2004). This relationship was found to exist by a large questionnaire survey conducted in Switzerland in 1997 (Siegrist, 2000). Results showed that perceived benefit had a significant impact on perceived risk. The study investigated four constructs relating to GM technology: perceived risks; perceived benefits; trust in institutions responsible for regulating GM technology; and acceptance of GM technology.

Overall, it has been demonstrated that when consumers are presented with product scenarios that deliver weak consumer benefits then acceptance is low, but that more consumers would accept GM products that deliver strong consumer benefits (Spetsidis & Schamel, 2002). Generally, it has been shown that GM food products are more acceptable when the beneficiaries are consumers, not producers (Kuznesof & Ritson, 1996).

However, although this may be true in some cases, figure 3.6 demonstrates that the situation is not always straightforward. It shows that different GM products and technologies are located at different places in the factor space depending on the extent to which they are perceived to provide advantages or to address need, and the extent to which they are perceived to present risk. Results were elicited from 25 respondents from the Reading area of the UK who were asked about 15 possible applications of genetic engineering in food production, medicine and agriculture (Frewer *et al*, 1997). The item 'low fat meat' demonstrates the inverse relationship. It is apparently viewed to be unethical and presenting high risks while at the same time is not viewed as demonstrating benefits or meeting need. However, if the relationship between risks and benefits was always inverse it would be expected that all items would lie close to a line running from the top left of the matrix to the bottom right. This is clearly not the case. It is interesting to note that those types of GM crops currently commercialised (i.e. ht and bt crops) are located fairly neutrally. A number of other GM food items are located in the lower part of the factor space suggesting that respondents thought there was little need for them and that they would offer little advantage. Interestingly, high yield crops and drought-tolerant crops are shown to be viewed more favourably since they are expected to offer more potential benefit and are not thought to present particularly high risks. Like the 'low fat meat' item these two types of crops support the notion that there is an inverse relationship between risks and benefits.

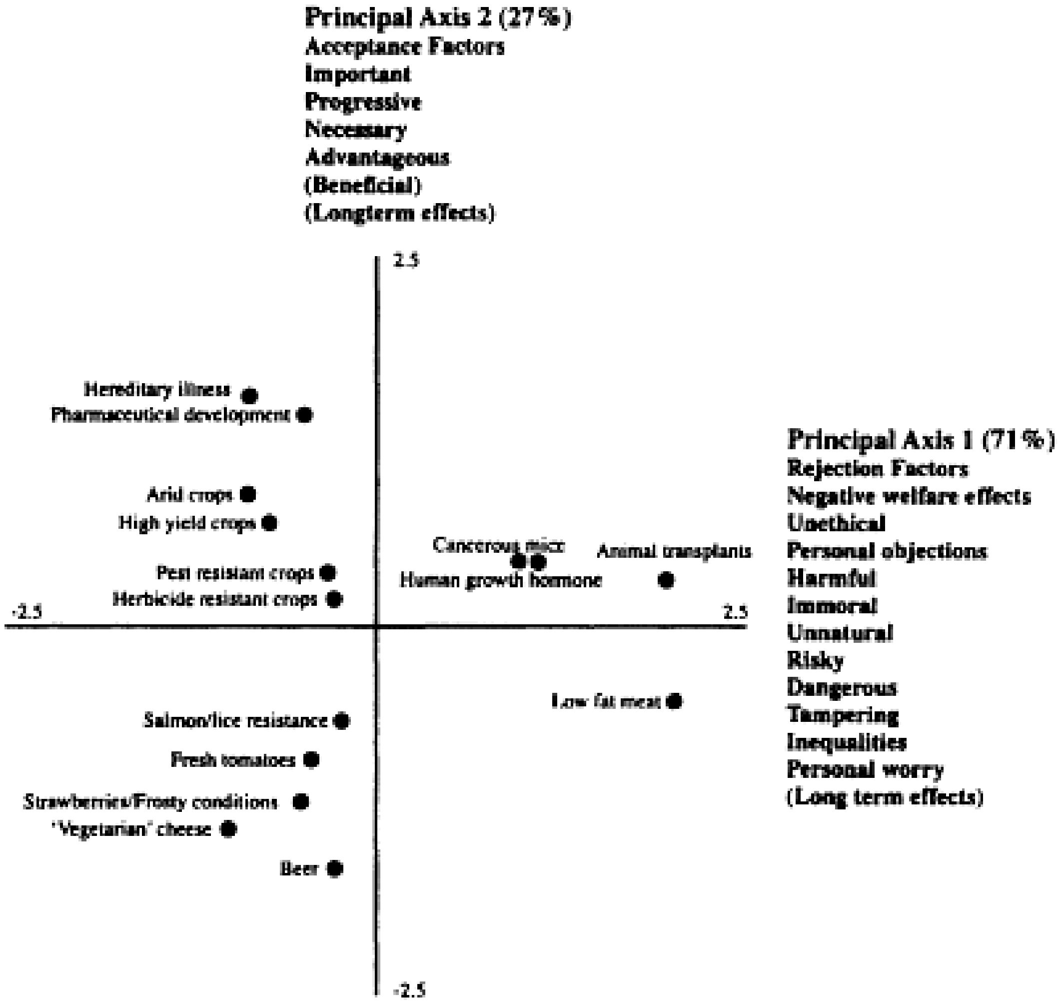

Figure 3.6: Location of GM products and technologies in two-dimensional factor space
Source: Frewer *et al*, 1997

The studies reviewed here demonstrate that although some people may be more accepting of GM technologies where they perceive consumer or environmental benefit, the relationship is a complex one and the promise of benefit may not be adequate to increase acceptability.

The extent to which the inverse relationship is likely to apply in the case of GM technology in food remains to be seen, since there are important issues of trust that may undermine this relationship. That is, if potential consumers do not have trust in those providing them with information about the potential benefits of the technology then the relationship may not hold true. Even with claims that certain modifications present, for example, environmental benefit, the product may remain unacceptable to potential consumers.

3.4.9 Conclusions

Based on all of the above, it is hypothesised that there is a number of factors likely to influence perceptions of risk of GM foods: Socio-demographic variables; where in the world is an individual or society; environmental values; attitudes to technology; trust in information sources and authorities; uncertainty surrounding the technology; the relationship between (perceived) risks and benefits, and others. Chapters four to seven aim to investigate which, if any, of the factors are most significant to different stakeholders. In the next section of this chapter, consideration moves on from consumers to producers, and reviews the literature on risk perceptions and farmer decision making.

3.5 Risk perceptions and farmer decision-making

3.5.1 Introduction

Chapters six and seven of this thesis address the issues of Scottish farmer attitudes towards GM technology, their risk perceptions and potential adoption decisions relating to the technology. Here there is a review of the relevant literature that has investigated risk perceptions and adoption decisions of farmers.

It is well established and long recognised that there are many sources of risk in agriculture (Harwood *et al*, 1999). These range from economic risks such as commodity and input price fluctuations, to risks of unpredictable yield levels and quality, to personal risks associated with farm accidents and occupational health issues. However, surveys conducted with farmers have found they are most concerned about institutional risks such as changes to government policy and regulation; production risks, specifically a drop in crop yields or livestock output; and price risks such as uncertainty in commodity prices. Results from workshops held with farmers in two separate years in the 1990s provided an importance ranking for 15 (year one) and then 16 (year two) sources of risk. Results showed that 'changes in technology' was given a mean score of 3.54 and 3.84 in the two years, on a scale of one 'not important' to five 'very important'. It was ranked eighth out of 15 in the first year of the workshops, and seventh out of 16 two years later (Harwood *et al*, 1999), suggesting that new technology is considered by farmers to be a relatively important risk.

As early as the 1960s, Rogers hypothesised that one of the personality variables that influenced adoption of new technology was that of attitudes to risk (Rogers, 1962). He commented that it was likely that earlier adopters have a better ability to cope with uncertainty and risk. Hence it can be assumed that there is a relationship between technology adoption and risk perceptions.

Results from a survey of beef producers, investigating perceptions of risk, and preferences for risk management, showed that attitudes to risk were a significant predictor of a producer's interest in additional risk management training (Hall *et al*, 2003). What is significant here is that attitudes to risk affected producer decisions in relation to addressing new management ideas (in this case risk management approaches). Hence they demonstrated the importance of farmers' risk attitudes to their adoption of new farm business management approaches, of which GM crops can be said to be one such approach.

There is a number of factors that have been presented in the literature as influencing farmer attitudes to risk and, through risk perceptions, to decision making and technology adoption. Generally these can be divided into characteristics of the farmer, for example age and education, and characteristics of the farm business, for example, type and size of enterprise. In addition, issues that are specific to the technology under consideration, are likely to be relevant. A number of studies are reviewed below that have addressed the issue of attitudes to risk and risk perception among farmers.

3.5.2 Characteristics of the farmer

Education

In a survey with livestock farmers in the Netherlands the socio-demographic variable of a farmer's education was found to be significantly related to a farmer's relative risk attitude (Meuwissen *et al*, 2001). The relative risk attitude was derived by presenting farmers with the four statements "I am willing to take more risks than my colleagues with respect to production (marketing / financial issues / farming in general)" and asking them to respond using a five point scale from 'don't agree' to 'fully agree'.

Age

It has been found that variables related to the circumstances of individual decision-makers on farms can have a significant impact on individual perceptions of the riskiness of different aspects of the farm business (Wilson *et al*, 1993). Hence, risk perceptions can be partially explained by reference to certain variables, that the authors refer to as framing variables. Their study ranked the degree of uncertainty associated with a number of characteristics of the farmer and the farm business. Differences in rankings of riskiness were explained by a number of variables that included the age of the farm manager. Hence age, that is the position of the operator in their lifecycle, was found to be an important factor for Arizona dairy producers in terms of providing the individual with a frame of reference for decision-making, and specifically for judging risks. Age was also identified in the study by Hall *et al* (2003) as being an important decision variable when considering options relating to perceptions of risk and preferences for risk management.

3.5.3 Farm business characteristics

The Wilson *et al* study (1993) referred to above, asked farmers to rank a number of farm business factors (such as input prices, product prices, the weather, farm size, government agricultural programmes, ownership structure, the availability of hired labour, and the availability of loans), in terms of levels of risk and uncertainty associated with those factors. They found that differences in rankings of riskiness were explained by variables such as farm size and ownership. Specifically, the number of lactating cows, the number of deeded acres, and the ownership structure of the farm business, were all found to be important factors in relation to uncertainty rankings by dairy producers. They concluded that the importance of enterprise size and land ownership indicated that income and net worth have an impact on how decision makers perceive their world. Importantly, the legal structure of the firm was shown to contribute to the level of risk perception and the farmer's frame of reference for decision-making.

In the survey referred to above with livestock farmers in the Netherlands, the socio-economic variables of gross farm income, solvency and farm size, were all found to significantly relate to a farmer's relative risk attitude (Meuwissen *et al*, 2001). One relevant result was that dairy farmers saw price risks as being very important while pig and mixed farmers were more likely to rank production risks as very important. Hence type of enterprise was important in distinguishing between perceptions of different risks. This may be relevant to the current study.

In another study (Flaten *et al*, 2005), organic farmers were found to have a significantly different attitude to risk than conventional farmers. Hence, again, enterprise type was related to risk perceptions. They also found that the number of dairy cows owned by a farmer was related to attitude to risk, hence farm size can be expected to be related to perceptions of risk. The authors found that increased farm income was also related to risk attitudes.

3.5.4 Influence of others

In the Theory of Planned Behaviour (TPB) Ajzen (1991) theorised that the intention to behave in a certain way was related to three variables: Attitudes, subjective norms, and perceived behavioural control. Subjective norms are a person's estimate of the social pressure to perform or not to perform a certain behaviour (Francis *et al*, 2004). Subjective norms in the context of the TPB have two interacting components: Beliefs about how other people would like them to behave, and the importance one attributes to the opinions of those other people or groups. Hence, within the variable 'subjective norms' an individual will determine the most important people or groups of people who would approve or disapprove of the behaviour, and estimate their reactions (that is, the third party) to the individual (in this case, the farmer) carrying out (or not) a certain activity or behaviour. The decision taken by farmers to adopt new technology or not may therefore be related to the influence of others, that is, the importance attached to the views and potential reactions of others. For example, Flaten *et al* (2005) found that farmers with both the highest and lowest levels of risk perceptions considered consumer demand risks to be of more importance than did those farmers with a medium level of risk perception. In another study, interviews were conducted with 17 British farmers, 11 of whom were involved in the farm scale evaluations, with the aim of investigating who influenced their decisions to introduce new technologies on their farm (Oreszczyn, 2006). Those found to significantly influence their decisions were: Defra; employees; family members; research institutes; farming organisations; landlords (for tenant farmers); agronomists; and supermarkets. The local community also became important only if and when the farmer was considering growing a controversial crop. Although the stated aim of the study was to investigate who influenced farmers' decisions to adopt new technologies, the reporting of the results suggests that these influencing organisations and individuals were mentioned as being important to farmers in general, in terms of running the farm business, or were important as sources of information or advice. They were not clearly important in directly influencing management decisions in relation to new technologies.

Nevertheless, the results are interesting in demonstrating the range of individuals and organisations that may influence farmers' decisions.

3.5.5 Media

In addition to those individuals and organisations noted above, it has been found that farmers' decisions may also be influenced to some extent by the media although this likely depends on the issue being reported and the way in which farming is presented in those reports (Oreszczyn, 2006).

3.5.6 Financial risks

The decisions made by farmers will generally have to take into consideration both financial risks and environmental risks. When considering GM crops specifically it may be that financial risks have greater importance to farmers than climatic, agronomic and environmental risks (Guehlstorf & Hallstrom 2005). This is largely due to the lack of GM markets in the EU and Japan. Thus when faced with a decision about whether or not to adopt GM crops farmers must obviously consider the potential (lack of) market for their product. Nevertheless, the extent to which this potential financial risk takes precedent over agronomic risks in the make-up of farmers' risk perceptions of GM crops is debateable.

3.5.7 Issues specific to the technology

While there is much in the general literature about farmers, risk perceptions, technology adoption and decision-making that is informative, there are also some GM technology-specific issues that are pertinent here. Thus, farmers' perceived risk of using GM seed may be related to such issues as their perception of potential environmental risks such as the emergence of 'superweeds', and risks related to excessive chemical use, acceptance of GM products in world markets, and to the provision of information about the technology by the government and seed companies (Guehlstorf & Hallstrom 2005). One of the main perceived risks affecting farmers possible adoption of bt and ht crops relates to concerns about the possible development of weed and pest resistance, whereby herbicides or pesticides cease to be effective (Oreszczyn, 2005). Further, some farmers have expressed concerns about the risk that planting GM crops could reduce the property value of their farm (Oreszczyn, 2005).

3.5.8 Other factors

Of the characteristics investigated by Flaten *et al* (2005), off-farm investments and location of the farm were found to have significant effects on farmers' perceptions of risk. This may be of relevance to the current study as one aim is to involve farmers from geographically diverse regions of Scotland. Botterill and Mazur (2004) described a wide range of issues that influenced farmers' concerns about GM technology in agriculture. These were how well the farmers understood the issue of GM technology (internal uncertainty); to what extent they believed the available information about the technology to be trustworthy (trust in information source); the voluntariness of the process of involvement (one of the psychometric paradigm dimensions of risk); the degree to which they the farmers felt they had some control over adoption of the technology or exposure of their land and crops to the technology (also a factor included in the psychometric paradigm dimensions of risk); and indeed how they viewed the morality of using the technology for food production.

3.5.9 Conclusions

These findings and claims from previous studies demonstrate that there is a range of factors influencing perceptions of risk among farmers, perceptions that are thereby related to decision-making such as technology adoption and management practices. However, note that Knowler and Bradshaw (2007) conclude that "there are few, if any, universal variables that regularly explain adoption of conservation agriculture". If conservation agriculture can be taken to be illustrative of producer decision-making relating to other production practices, this could be relevant to the current study.

3.6 Conclusions

To conclude this chapter, there is an important distinction between technical definitions of risk and associated risk management approaches, and the constructionist nature of risk perceptions formed by 'non-experts'. This distinction requires that understanding responses to new technologies such as GM food and crops, requires consideration of risk perceptions. There is a number of factors that have been found to influence risk perceptions, and therefore, decision-making among both consumers and producers. According to the literature these include:

- Socio-demographic factors such as age, gender and education
- Environmental values
- General attitude to new technologies

- Media coverage
- Initial impressions
- Trust
- Psychometric paradigm dimensions of risk
- Associated benefits
- How the question is posed
- A range of business structural factors such as farm size, ownership structure and enterprise type (farmers only)

This chapter therefore paves the way for the four chapters that follow, each of which have sought to investigate a range of the factors discussed above, in terms of their significance for different groups of people, drawing on different disciplines and areas of investigation.

Chapters four and five investigate the extent to which a number of the factors identified above can be said to influence the perceptions of risk of consumers (the demand side). Chapter four focuses on consumers in countries throughout the world, while chapter five targets those potential consumers in Scotland likely to have the most negative risk perceptions. The chapters utilise different approaches. Chapter four draws on the environmental economics literature to investigate GM food through meta-analyses of stated and revealed preference studies. Chapter five draws on the psychometric paradigm approach to risk evaluation by addressing a number of the dimensions of risk, but also more broadly utilises sociological approaches by investigating the importance of socio-demographic characteristics, environmental values and other factors. However the key focus of chapter five is an investigation of the relationship between risks and benefits.

Chapters six and seven take a different perspective by targeting the views of Scottish farmers (the supply side) and their perceptions of the risks of GM technology in agriculture. Chapter six draws on the farmer decision-making and technology adoption literature to investigate the factors influencing risk perceptions and potential adoption decisions. Chapter seven delves deeper into farmer attitudes to GM technology and aims to identify different opinion groups based on their risk and benefit perceptions.

Chapter eight provides discussion, drawing together all the findings, and presenting the implications of the results. The final chapter, chapter nine, conclusions, briefly recounts the key findings and implications, and suggests areas for future research.

Chapter 4: Valuing hypothetical response to GM food[1]

4.1 Introduction

The aim of the work presented in this chapter was to investigate contingent values associated with GM food, drawing on studies from the field of environmental economics. Overall, the intention was to elicit average values from groups of similar valuation studies. Accordingly, this chapter presents a review of 25 valuation studies addressing the issue of valuation of GM food, and details of three meta-analyses conducted subsequently.

Following the initial summation of studies and the derivation of the value associated with each of the three meta-analyses, a subsequent objective was to explain factors that influenced those values. Thus, relevant questions are: Are there certain cultural variables such as participant group and country of study that influence the magnitude of contingent values? Are the values best explained by design features such as the nature of the question asked and the elicitation technique used?

The chapter is structured as follows. The next section presents the background to the chapter, discussing the economic concept of risk, the necessity of drawing on hypothetical studies, and the use of meta-analysis. This is followed by a section outlining the methodological stages. After that, details are presented about the studies included in the meta-analyses, the assumptions made about how certain factors may have affected the values produced by the studies, and the results from analysis. The section that follows, discusses and analyses the results, and the chapter ends with conclusions about the factors shown by this part of the thesis to influence contingent values.

4.2 Background

4.2.1 Economics and risk

Of all the social science approaches to the investigation of risk, the economic concept is closest to the technical approach (Renn, 1998). The main difference is that the notion of physical harm or undesirable effects included in technical approaches is transformed into the notion of 'utility' in economics. Thus, risk is conceptualised as expected utility. Utility describes the degree of satisfaction or dissatisfaction associated with a

[1] Note that a version of this chapter has been published as a book chapter (Hall, C., Moran, D. & Allcroft, D., 2006. Valuing perceived risk of genetically modified food: A meta-analysis. In: Pearce, D. (ed). Environmental valuation in developed countries: Case studies. Edward Elgar Publishing Ltd, Cheltenham. Pp97-131).

possible action or transaction. In economics, utility is measured by the amount of money that someone is willing to pay for a change that provides a higher degree of utility than remaining at the status quo. The underlying assumption is that individuals try to maximise their utility based on the information and time that is available to them for balancing pros and cons (or benefits and risks) (Zinn, 2008). Thus, random utility theory provides the basis for modelling choices, and people are assumed to maximise utility as expressed in the following equation:

(1) $U_{ij} = V_{ij} + \varepsilon_{ij}$

where U_{ij} represents the utility of the ith individual for the jth alternative. Utility therefore has two components, a systematic component V_{ij} that is a function of product attributes (if considering, for example, GM food) and socio-demographic characteristics, and a random component ε_{ij} (Baker & Mazzocco, 2002). In this way, the utility function captures attitudes to (or perceptions of) risk (Statistical and Applied Mathematical Sciences Institute, 2007).

Historically, economists generally approached the study of risk using a strict conceptualisation of rational action (Taylor-Gooby & Zinn, 2006). However, evidence of inconsistencies in the way that people deal with decisions about risk, have proved to be a challenge. A rational model of decision-making places strict requirements on peoples' capacity to process information and estimate probabilities. Economists have had to develop the idea of 'bounded rationality' to capture the limits of peoples' cognitive capacities. This has allowed risk responses to be analysed more successfully. Some authors claim that there are three dimensions to risk, according to economic theory. These are the final outcomes of different 'states of nature', subjective beliefs about the probability that each outcome will occur, and willingness to accept risk (Gerking & Harrison, 2006).

4.2.2 The use of hypothetical studies

As discussed in chapter two, adoption of GM crops continues to expand in certain countries, most notably the USA, Canada, Argentina and Brazil. The future of GM technology elsewhere, most significantly within the EU, remains uncertain. As noted, relevant legislation is now in place within the EU, governing both the commercial release into the environment of GM crops, and labelling of GM food products. However, there remains a large degree of uncertainty surrounding the issue of whether or not consumers are likely to be willing to buy GM products. Some of the possible reasons for this, and relevant issues, have been outlined in chapters two and three.

It is not possible to demonstrate how much consumers value GM food, relative to conventional or organic produce, using market-based information. There are two reasons for this. First, in the EU, there is little or no GM food on the market. Second, in countries where GM products and GM food ingredients are widely available, they are not labelled as such. For these reasons, hypothetical studies are useful.

4.2.3 Meta-analysis

As noted above, the purpose here was to derive a 'value' for GM foods, using hypothetical studies. In some situations it may be possible to utilise (transfer) a value from a single study most similar to the policy or issue being analysed. However, where there are numerous studies, as in this case, it may be more robust to draw an inference from the wider range of studies. This is where meta-analysis has value. Meta-analysis, and the related approach of systematic reviews, are now established in environmental economics and health studies respectively, as a way of summarising the findings of a body of similar studies. Meta-analyses that have been conducted in the field of environmental economics cover a range of topics such as air quality (Smith & Huang, 1995), groundwater quality (Poe *et al*, 2001), endangered species (Loomis & White, 1996), wetlands (Brouwer *et al,* 1997; Woodward & Wui, 2001), and woodland recreation values (Bateman & Jones, 2003). In this context, the method helps to provide consensus on value estimates for goods or features that are not observable in the market place, and to investigate factors that explain variation within and between different studies (Poe *et al*, 2001).

4.3 Methodology

4.3.1 Identifying studies for inclusion

A range of information sources was used to identify studies for inclusion. This included databases such as EconLit and ArticleFirst and on-line sources such as the University of Minnesota's web-based Agecon Search – "A full text library of agricultural and applied economics scholarly literature"[2]. In addition, searches were conducted using the EVRI online database of environmental valuation studies[3]. A range of other books, journals and conference proceedings was also used. The search terms used included a combination of methodological terms and terms relating to GM food. Thus the methodological terms

[2] http://agecon.lib.umn.edu/
[3] www.evri.ca

included ‘willingness to pay’, ‘contingent valuation studies’, ‘choice experiments’, and ‘auction experiments’. All of these terms were combined with ‘GM’, ‘GMO’, ‘biotechnology’, ‘biotech’, ‘genetic engineering’ and ‘genetically modified’.

4.3.2 Deriving mean values

Having collated relevant studies, the next methodological stage was to harmonise the values elicited by the individual studies. The mean values constituted the dependent variables for the purpose of the meta-analyses. The dependent variable took the form of a percentage value (of spend on individual food item or on weekly food bill). In most cases this was a comparable statistic reported in study results. In studies where information was presented as a cash figure, the contemporary retail food price of that item was used to derive a percentage figure that could then be included in the meta-analysis. In some cases, certain assumptions had to be made. For example, in a study by Buhr *et al* (1993), which presented participants with a meat sandwich, the assumption was that the price of a meat sandwich bought in a shop would cost twice the price of a loaf of white bread, which in 1992 was $0.75. Hence that figure was used to convert the result to a percentage. Some studies were rejected (for example, Fox *et al*, 1994), as they could not be satisfactorily converted.

4.3.3 Identifying independent variables and hypotheses

Having identified studies, and harmonised values from those studies, the next part of the methodology involved identifying what factors might be relevant in influencing the values derived, and hypothesising what their influence may be. The factors under consideration became the independent variables within the meta-analyses. The choice of independent variables was influenced by three criteria. Choice was necessarily restricted by the characteristics of the studies included in the meta-analyses. The choice of variables was also informed by previous meta-analyses conducted in the field of environmental economics. In addition, an attempt was made to investigate variables that corresponded with the factors discussed in chapter three.

4.3.4 Conducting analysis

Having identified studies, harmonised the values, and then chosen relevant independent variables to investigate, the next stage was descriptive statistical analysis of the dependent variable values, and examination of the characteristics of the three data sets. This was followed by T-tests and ANOVA to investigate where there were statistically significant differences between means. In addition, attempts were made to investigate interaction effects within one of the three data sets, by conducting two way ANOVA.

4.4 Results

4.4.1 The studies

In all, 24 stated preference studies (CV studies, auction experiments and choice experiments) and one revealed preference study (James *et al*, 2002) were identified whose values could be successfully harmonised. Where a single study provided numerous values, several data points were obtained. For example, Chern *et al* (2002) presented WTP figures for four different countries. Thus the 25 studies provided a total of 67 values. Although all studies had investigated the issue of GM food it became clear that they addressed different questions. Specifically, three distinct groups could be identified. First there were studies that had asked how much consumers would be willing to pay (WTP) to avoid products which contained GM ingredients. A smaller number of studies had asked how much consumers would be WTP to purchase GM foods with traits such as less fat (Buhr *et al*, 1993), or which required less pesticides in production (Boccaletti & Moro, 2000). Others still asked how cheap GM food would need to be in order to induce consumers to buy (see for example, Burton *et al*, 2001; Mendenhall & Evenson, 2002; Noussair *et al*, 2001; Chen & Churn, 2004). In this case the question can be described as willingness to accept (WTA) compensation to forego a benefit. The benefit foregone is the perceived risk-free status and familiarity of non-GM food[4]. To summarise, there were:

- Studies that asked how much respondents were **WTP for GM-free** (or to avoid GM).
- Studies that asked how much respondents were **WTP for GM** with clear benefits.
- Studies that considered how much respondents were **WTA** as compensation for GM (or how much cheaper it would have to be before respondents would buy).

Two of the groups refer to GM food, the third refers to GM-free food. In the case of the studies relating to GM food, the distinction lies in whether GM food was presented as being beneficial, or unknown and potentially risky. In the latter case, the studies presented GM food as being a new and potentially risky alternative to conventional food. As the third set of studies refers to GM-free food it actually concerns a different product to the other two. These differences between the three sets of studies made it necessary to treat them as

[4] A number of studies asked different questions relating to more than one of the data sets.

different datasets and conduct three separate meta-analyses, rather than analysing the full 67 values as one dataset, as was the original intention. Tables 4.1, 4.2 and 4.3 summarise the 25 studies. A number of details are included. Specifically, the tables include details relating to the study such as author(s) and date of study, along with other information from the studies about the factors investigated (such as country of study and elicitation technique).

Table 4.1 Studies included in the meta-analysis

Study number	Author (s)	WTP Question	Number of WTP values	WTP values
1	Buhr *et al*, 1993	WTP for GM free	1	23% to avoid GM
2	Wang *et al*, 1997	WTP for GM free	1	16% extra for rBST-free milk (50% of respondents)
3	Kuperis *et al*, 1996	WTP for GM free	1	13% for GM free
4	Boccaletti & Moro, 2000	WTP for GM with benefits	4	8% for GM foods which reduce the use of pesticides 8% for GM foods which have increased nutritional properties 5% for GM foods with improved taste 5% for GM foods with longer shelf life
5	Noussair *et al*, 2002	WTA GM without benefits	1	27% reduction in bid with awareness of GM
6	Lusk *et al*, 2003	WTP for GM free	4 (different countries)	220% extra for GM-free (France) 200% extra for GM-free (Germany) 182% extra for GM-free (UK) 143% extra for GM-free (USA)
7	Burton *et al*, 2001	WTP for GM free	6 (3 consumer subgroups, both sexes)	26% extra for GM-free (infrequent purchaser of organic food, male) 49% extra for GM-free (infrequent purchaser of organic food, female) 66% extra for GM-free (occasional purchaser of organic food, male) 130% extra for GM-free (occasional purchaser of organic food, female 352% extra for GM-free (committed purchaser of organic food, male) 472% extra for GM-free (committed purchaser of organic food, female
8	Loureiro & Hine, 2002	WTP for GM free	1	5% extra for GM-free (47% of respondents)
9	James & Burton, 2003	WTA GM without benefits	4 (by gender and type of GM)	14% reduction required to purchase GM (female - plants only) 4% reduction required to purchase GM (male - plants only) 52% reduction required to purchase GM (female - plants and animals) 26% reduction required to purchase GM (male - plants and animals)
10	Mendenhall & Evenson, 2002	WTP for GM free	1	20% extra for GM-free (50% of respondents)
11	Lusk *et al*, 2001	WTP for GM free	2 (different parts of study)	33% extra for GM-free 24% extra for GM-free
12	Noussair *et al*, 2001	WTP for GM free and WTA GM without benefits	2	8% extra for GM-free 38% reduction in bids for product labelled 'contains GM'
13	Moon & Balasubramanian, 2003	WTP for GM-free	2 (different countries)	12% extra for GM-free (USA) 19% extra for GM-free (UK)
14	Baker & Mazzocco, 2005	WTA GM without benefits	1	40% less for GM
15	Huffman *et al*, 2003	WTA GM without benefits	3 (different products)	14% less for GM (vegetable oil) 14% less for GM (tortilla chips) 14% less for GM (russet potatoes)

16	Lusk, 2003	WTP for GM with benefits	2 (different auction types)	25% more for GM rice 43% more for GM rice
17	Chen & Chern, 2004	WTA GM without benefits	3 (different food items)	7% less for GM vegetable oil 22% less for GM salmon 15% less for GM cornflakes
18	James *et al*, 2002	WTP for GM	4 (different stores)	6% less for GM sweetcorn 6% extra for GM sweetcorn 8% extra for GM sweetcorn 2% extra for GM sweetcorn
19	McCluskey *et al*, 2003	WTA GM without benefits	2 (different food items)	60% reduction needed for GM noodles 62% reduction needed for GM tofu
20	Chern *et al*, 2002	WTP for GM free	4 (different countries) (student survey)	Student survey 56% extra for GM-free (US) 37% extra for GM-free (Japan) 62% extra for GM-free (Norway 19% extra for GM-free (Taiwan)
			4 (2 different countries, 2 products) (general population survey)	General population survey 54% more for salmon not fed GM (Norway) 67% more for GM-free salmon (Norway) 41% more for salmon not fed GM (US) 53% more for GM-free salmon (US)
21	Grimsrud *et al*, 2004	WTA GM without benefits	2 (different food items)	50% reduction needed for GM bread
22	Tonsor *et al*, 2005	WTP for GM-free	3 (different countries)	194% extra for beef not fed GM feed (UK) 56% extra for beef not fed GM feed (Germany) 61% extra for beef not fed GM feed (France)
23	Li *et al*, 2002	WTP for GM rice – with benefits WTP for GM Soybean oil – without benefits	2 (different products)	38% extra for GM rice 16% extra for GM soybean oil
24	Loureiro & Bugbee, 2005	WTP for GM tomatoes with benefit	5 (different benefits)	3% extra for tomato with enhanced nutritional value 2% extra for tomato with reduced pesticide 1% extra for tomato with increased shelf life 0% extra for tomato providing increased profit for farmers 4% extra for tomato with enhanced flavour
25	Wachenheim & VanWechel, 2004	WTP for GM-free	3 (different products)	11% extra for GM-free potato chips 10% extra for GM-free cookies 14% extra for GM-free muffins

Table 4.2 Study details (a)

STUDY NUMBER	YEAR OF STUDY	NO OF PARTICIPANTS	COUNTRY OF STUDY	DETAILS OF WTP/WTA QUESTION
1	(Paper 1993)	106	USA	Bid to exchange GM meat sandwich for conventional sandwich
2	1995	702	USA	WTP a premium for GM-free
3	1995	1240	Canada	Extra percentage of weekly food bill to restrict use of biotechnologically derived hormones
4	1999	200	Italy	Extra for GM food with positive attributes
5	1999	112	France	Extra for GM food without positive attributes
6	2000	1065	France Germany UK	WTP for GM free
7	2000	228	UK	WTP for GM free
8	2000	437	USA	WTP for GM free
9	2000	370	Australia	Extra for GM food without positive attributes and for GM-free
10	2000	54	USA	WTP for GM free
11	2000	50 (32 + 18)	USA	Bidding for GM free corn chips
12	2000	97	France	WTP more for ‘sans GM’ and reduction in bids for ‘avec GM’
13	2000	3060 2570	USA UK	WTP for GM-free
14	2001	116	USA	Lower price required before willing to buy GM
15	2001	174	USA	Lower price required before willing to buy GM
16	2001	574	USA	WTP more for GM rice with positive benefit
17	2001	141	USA	Lower price required before willing to buy GM
18	2001		USA	Both GM and non-GM product offered at same price or GM cheaper or GM more expensive
19	2001	400	Japan	Willingness to buy GM at lower price than conventional
20	2001 (student survey)/ 2002 (general population survey)	617 (student survey) 450 (general population survey)	Japan Norway Taiwan USA	WTP for GM free
21	2002	400	Norway	Price reduction required to induce consumers to buy GM
22	2002	248	UK Germany	WTP for beef not fed GM feed

			France	
23	2002	599	China	WTP for GM rice with product enhancing attributes
				WTP for soybean oil without product enhancing or process enhancing attributes
24	2003	164	USA	WTP for GM with benefits
25	2003	112	USA	WTP for GM-free

Table 4.3 Study details (b)

Study number	General food or GM specific survey	Food item	Participant group	Survey distribution method	Elicitation technique
1	GM specific	Meat sandwich	Students	In-person (University)	Auction (Vickrey auction)
2	General food survey	Milk	General population	Telephone	Open-ended CV question
3	General food survey	General	General population	Telephone	Choice experiment
4	GM specific	General	General population	Telephone	Payment card
5	GM specific	Chocolate bar	General population	In-person	Auction (Vickrey auction)
6	GM specific	Beef steak	General population	Mail	Choice experiment
7	General food survey	General	General population	Mail	Choice model and open-ended CV questions
8	General food survey	Potatoes	Shoppers	Supermarket	Payment card
9	General food survey	General	General population	Mail	Choice experiment and open ended CV question
10	GM specific	General	General population	Telephone	Open-ended CV question
11	GM specific	Corn chips	Students	In-person (University)	Auction (First and second price sealed bid auctions)
12	GM specific	Soya products	General population	In-person	Auction (BDM random price mechanism)
13	GM specific	Breakfast cereal	General population	Mail (US) On-line (UK)	Payment card
14	GM specific	Bananas	General population	Mail	Choice experiment
15	GM specific	Vegetable oil Tortilla chips Russet potatoes	General population	In-person	Auction (Random nth price auction -combines Vickrey auction and BDM random price mechanism)
16	GM specific	Rice	General population	Mail	Dichotomous choice CV questions (Double-bounded)
16	GM specific	Vegetable oil Salmon Cornflakes	General population	Mail	Dichotomous choice CV questions
18	GM specific	Sweet corn	Shoppers	Supermarket	Revealed preference in-store purchase
19	GM specific	Noodles Tofu	Shoppers	Supermarket	Dichotomous choice CV questions
20	GM specific	Vegetable oil (student survey) Soybean oil (general population survey) GM-fed salmon (general population survey)	Students General population	In-person (University) Telephone (general population survey)	Dichotomous choice CV questions (student survey) Choice experiment (general population survey)

		GM salmon (general population survey)			
21	GM specific	Bread Salmon	Shoppers	Supermarket	Dichotomous choice CV questions
22	GM specific	Beef steak	Shoppers	In-person	Choice experiment
23	GM specific	Soybean oil Rice	Shoppers	In-person	Dichotomous choice CV questions (Double-bounded)
24	GM specific	Tomatoes	General population	Mail	Payment card
25	GM specific	Potato chips Cookies Muffins	Students	In-person	Auction (Random nth price auction)

4.4.2 Independent variables and hypotheses

In identifying variables to investigate, it became clear that there were two main factors of relevance here. These were cultural factors and question format factors. Given the nature of the information in common across the studies, it was possible to examine these two factors in some detail, and to break them down into a number of components. In all, seven variables were examined: Three contextual factors and four relating to question format. Under contextual factors the following were considered: Country of study, participant group, and year of study. Under question design factors were elicitation technique, distribution method, description of food in survey, and survey topic. These are discussed below. It should be noted that it was not possible to analyse all these seven factors in all three datasets because some factors did not have values in all categories. Hence in the 'WTP for GM food with benefits' dataset, five factors were examined; all seven factors were examined in the 'WTP for GM-free' dataset; and six factors were considered in the 'WTA GM without benefits' dataset.

Cultural factors

In this part of the thesis it was possible to examine a number of cultural factors, and investigate how, if at all, they impacted on WTP/WTA values for GM food. Specifically, the cultural factors investigated were date of study, country of study, and the type of participant who was being asked to respond to questions about their contingent values associated with GM food. A number of assumptions were made about how these factors might be expected to impact on WTP/WTA values and these are described below. Each of the factors was defined by a number of categories, dependent on the information contained within the studies examined, and also based on the literature relating to the GM debate. These categories and the justification for them are also described below (see table 4.4 for a summary of the hypotheses and categories).

Year of study

There were two categories under the factor 'year of study'. These were '1998 or earlier', and '1999 or later'. Nineteen ninety nine was chosen as a watershed because in that year there was an "outburst of media hysteria relating to genetically modified food products" (Burrell, 2000). It was assumed that pre-1999 respondents considered GM food to be no more risky than conventional food, and would not be WTP such a high premium for GM-free food. Similarly, GM food would not need to be a lot cheaper than conventional food before consumers would be willing to buy.

Survey country

Again, there were just two categories within this factor, the 'USA' or 'the rest of the world'. It has been widely reported that US consumers have been less suspicious of GM foods (see for example Moon & Balasubramanian, 2003). It was therefore assumed that values obtained from studies conducted in the USA would yield lower values than studies conducted elsewhere in the world.

Type of participant

It can be assumed that values may differ depending on the participant group. There were three category groups identified as being culturally different groups, based on the context in which they were surveyed. These groups were: 'Shoppers' (for surveys that were conducted in stores), 'students' (for surveys that were conducted in university agriculture departments) and 'general population' (for all other surveys). The assumption here was that 'shoppers' and 'students' would provide lower values because of having a more realistic setting and more knowledge of the subject, respectively.

Study design factors

Given the nature of the studies being collated and examined in this chapter, it was possible to investigate a number of issues relating to study design and question format, and to see to what extent, if any, these had an impact WTP/WTA values. Specifically, the factors considered were:

- Elicitation format – that is, the type of approach used;
- Distribution method – that is, how the study was presented to participants (for example, postal survey, telephone and so on);
- Whether the study referred to GM food specifically, or whether it was a general survey of food (and hence whether GM was 'hidden' amongst other food-related issues); and
- Whether the survey WTP/WTA question related to a specific food item or whether it related to overall food expenditure.

Originally it was also the intention to include response rate as a factor. However it transpired that there were a large number of missing values (10 of the 25 studies) and it was not included. Assumptions were made about how these factors might be expected to impact on contingent values. These hypotheses are described below, along with a description of the categories within the factors.

Elicitation technique

With six categories, this factor had the most categories of all factors. These were: ‘Auction’, ‘payment card’, ‘choice experiment’, ‘dichotomous choice CV question’, ‘open-ended CV question’, and ‘revealed preference, in-store purchase’. The use of open-ended elicitation format has been found to result in lower average WTP amounts than any other format (Brouwer *et al*, 1997). The dichotomous choice (DC) format has shown the highest average WTP, followed by the iterative bidding format (auction experiments), and then payment card method. Assumptions were therefore based on these earlier findings. There appears as yet to be no indication as to how the use of choice experiments might affect values obtained and thus no assumption was made about this elicitation technique.

Distribution method

Under the factor ‘distribution method’ there were five possible categories. These were: ‘Mail’, ‘telephone’, ‘in-person’, ‘on-line’ and ‘supermarket’. It was assumed that supermarket surveys would yield lower values because the setting was more realistic (that is, individuals were in a ‘real’ food shopping environment), and would help to avoid unrealistically high values. Further, there was an assumption that personal interviews and telephone surveys would yield lower values as they allow more opportunity for clarification. Personal interviews (that is, in-person studies) have been found to yield a lower average WTP than mail surveys (Brouwer *et al*, 1997). Thus, it was assumed that surveys conducted by mail would result in the highest values. On-line was assumed to have the same effect as mail surveys.

Description of food in survey

The two categories within this factor were named ‘food item’ and ‘GM general’. The assumption was that a survey asking respondents about a specific food item would result in higher values than a general basket of food (weekly food expenditure). This assumption is based on the idea that, for example, 25% extra for a single item is not so large in peoples’ minds as 25% extra on the whole of their weekly food bill.

Survey topic

There were two categories within this factor, either 'GM specific survey' or 'general food survey'. It was assumed that if the survey topic was specifically about GM food then the value would be greater. This was because a GM specific survey gives the subject an importance that it might not have in peoples' minds if it is one subject amongst others in a general food survey.

Table 4.4: Assumptions about impact of factor on values

FACTOR	IMPACT	CATEGORY
Survey year	1998 or earlier = smaller WTP for GM-free or smaller reduction required for GM without clear benefits 1999 or later = larger WTP for GM-free or greater reduction required for GM without clear benefits	1998 or earlier 1999 or later
Survey country	USA = smaller WTP for GM-free or smaller reduction required for GM without clear benefits Rest of the world = larger WTP for GM-free or greater reduction required for GM without clear benefits	USA Rest of world
Participant group	Shoppers = smaller WTP for GM-free or smaller reduction required for GM without clear benefits Students = smaller WTP for GM-free or smaller reduction required for GM without clear benefits General population = larger WTP for GM-free or greater reduction required for GM without clear benefits	Students Shoppers General population
Elicitation technique	Dichotomous choice = greatest WTP for GM-free or greater reduction required for GM without clear benefits Iterative bidding (auction) = next greatest WTP for GM-free or greater reduction required for GM without clear benefits Payment card = smaller value than two above, greater than open-ended Revealed preference = smaller WTP for GM-free or smaller reduction required for GM without clear benefits Open-ended = smallest WTP for GM-free or smallest reduction required for GM without clear benefits No assumption made regarding impact of choice experiments	Auction Payment card Choice experiment Dichotomous choice CV question Open-ended CV question Revealed preference in-store purchase
Survey distribution method	Supermarket = smaller WTP for GM-free or smaller reduction required for GM without clear benefits Personal interviews and auctions = smaller WTP for GM-free or smaller reduction required for GM without clear benefits Phone = greater WTP for GM-free or greater reduction required for GM without clear benefits Mail = greatest WTP for GM-free or greatest reduction required for GM without clear benefits On-line = As for mail	Mail Telephone In-person Supermarket On-line
Description of food in survey (general or specific)	Named food item = larger WTP for GM-free GM food in general = smaller WTP for GM-free	Named food item GM general
Survey topic	GM specific survey = greater WTP for GM-free or greater reduction required for GM without clear benefits General food survey = smaller WTP for GM-free or smaller reduction required for GM without clear benefits	GM specific survey General food survey

4.4.3 Descriptive statistical analysis

Comparing the three data sets

Table 4.5 presents summary statistics for each of the three data sets. The mean values show that, on average, respondents were WTP 81% more to avoid GM food, but were willing to accept GM food at a 27% discount. In addition, respondents were on average WTP 11% extra for GM food with benefits.

Table 4.5 Summary statistics

	SUMMARY STATISTICS FOR WTA GM FOOD WITHOUT BENEFITS	SUMMARY STATISTICS FOR WTP FOR GM-FREE FOOD	SUMMARY STATISTICS FOR WTP FOR GM FOOD WITH BENEFITS
NUMBER OF VALUES	17	34	16
MEAN	27% (17%, 37%)	81% (44%, 117%)	11% (4%, 18%)
MEDIAN	22%	45%	6%
MINIMUM	4%	5%	0%
MAXIMUM	62%	472%	43%
RANGE	58%	467%	43%
STANDARD DEVIATION	19%	104%	13%

Note: The percentage values in the second column refer to how much cheaper GM food has to be than conventional food prices before consumers are willing to buy.
The percentage values in the third and fourth columns refer to a percentage premium over and above the existing conventional food price.
The figures in brackets are 95% confidence intervals.

Descriptive statistical procedures were used to explore the dependent variable, or WTP/WTA value, of each of the data sets. Analysis was then carried out to compare values with the range of variables, the cultural and study design factors described above, including date of study, country of study, survey distribution method and elicitation technique. The purpose of this was to give some indication of what factors may be affecting values.

In the following section, consideration is given to each of the datasets in turn, and an examination is undertaken of each of the factors in order to draw conclusions about what might impact on the mean WTP/WTA values. For each dataset, a table of results is presented and also boxplots for each of the categories. The plots are included as they provide a clear visual representation of the mean values of each of the categories within the factors. This is useful, as the aim is to derive general messages about impacting factors rather than focusing on actual values.

WTA GM food without benefits

The results in table 4.6 show the number of observations, minimum and maximum values, standard deviation, and mean WTA value for each category of each factor for the WTA dataset. This allows comparison of the different categories and suggests how some factors may be influencing values. Results show that the mean WTA value from surveys conducted in the USA was 17%, compared to 37% for surveys conducted in the rest of the world. Results for the participant group factor show that ‘shoppers’ required a greater discount than the ‘general population’ before expressing a willingness to purchase GM food. The results for the ‘elicitation technique’ show that ‘DC CV studies’ elicited the highest average value and ‘revealed preference’ the lowest. The highest mean WTA value relating to distribution method was from those conducted in ‘supermarkets’, at 45%. The other two formats (in-person and mail) elicit similar values (21% and 23% respectively). In the factors, ‘description of food in survey’ and ‘survey topic’ there is very little difference between values of categories. For illustrative purposes, boxplots have been included for all the factors.

Table 4.6 WTA GM without benefits

FACTOR	CATEGORY	NUMBER OF OBSERVATIONS	MIN VALUES	MAX VALUES	STANDARD DEVIATION	MEAN WTA
COUNTRY of study						
	USA	8	6	40	11	17
	Rest of the World	9	4	62	21	37
PARTICIPANT						
	Shoppers	4	6	62	26	45
	General population	13	4	52	14	22
ELICITATION technique						
	Auction	5	14	38	11	21
	Choice experiment	5	4	52	19	27
	Dichotomous choice CV questions	6	7	62	24	36
	Revealed preference	1	6	6	-	6
DISTRIBUTION method						
	In-person	5	14	38	11	21
	Mail	8	4	52	16	23
	Supermarket	4	6	62	26	45
GEN_OR_SPEC_food (Does survey deal with a general ‘basket of food’ or a specific food item?)						
	General	4	4	52	21	24
	Specific	13	6	62	20	28
GEN_OR_SPEC_survey (Is survey a general food survey or GM specific?)						
	General food survey	4	4	52	21	24
	GM specific	13	6	62	20	28

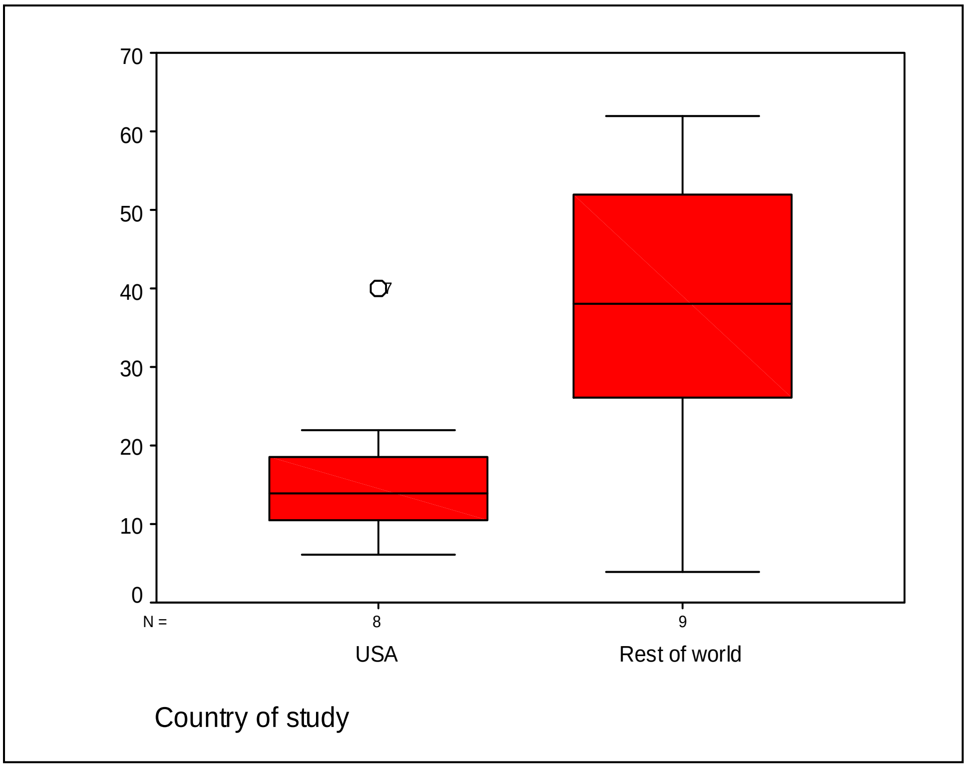

Figure 4.1: Boxplots of mean WTA GM without clear benefits by country of study

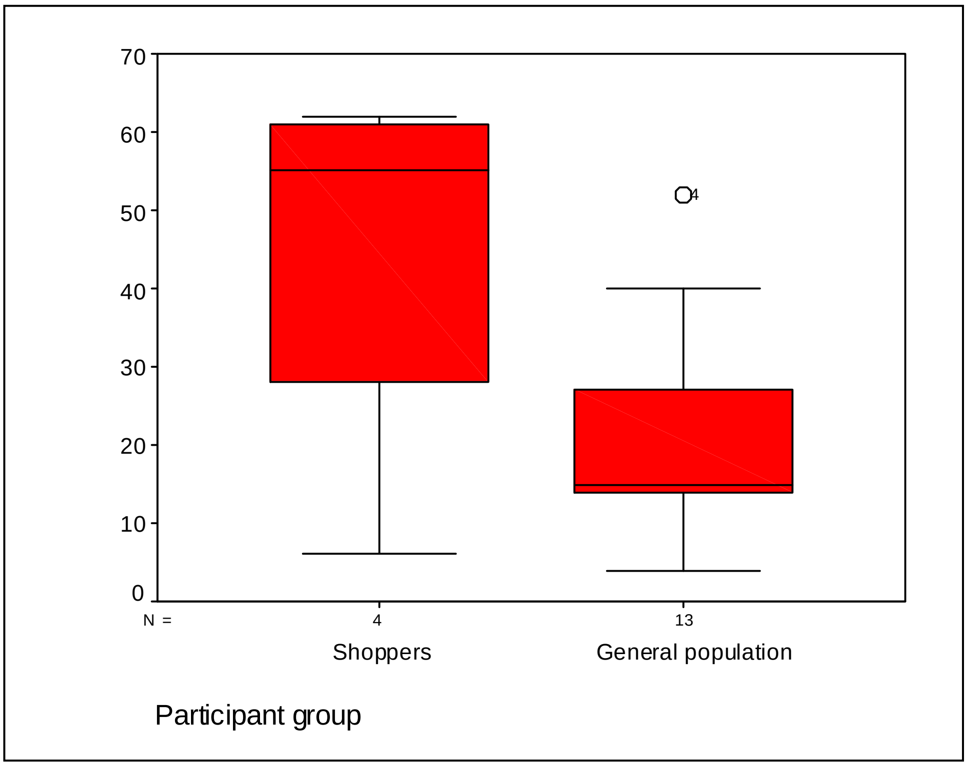

Figure 4.2: Boxplots of mean WTA GM without clear benefits by participant group

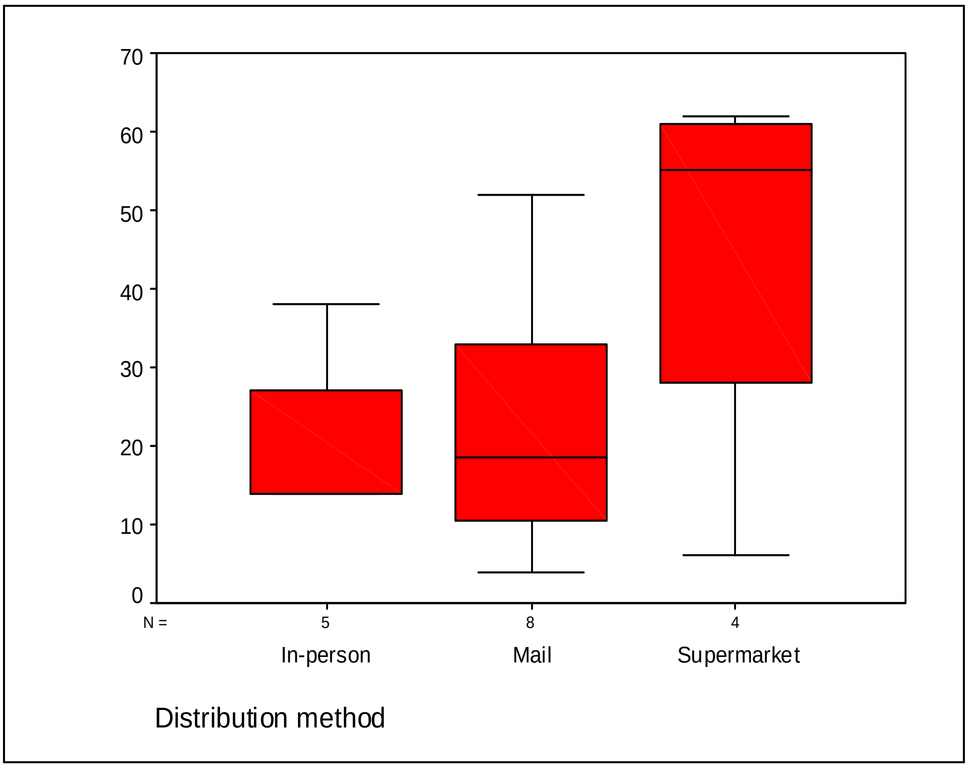

Figure 4.3: Boxplots of mean WTA GM without clear benefits by distribution method

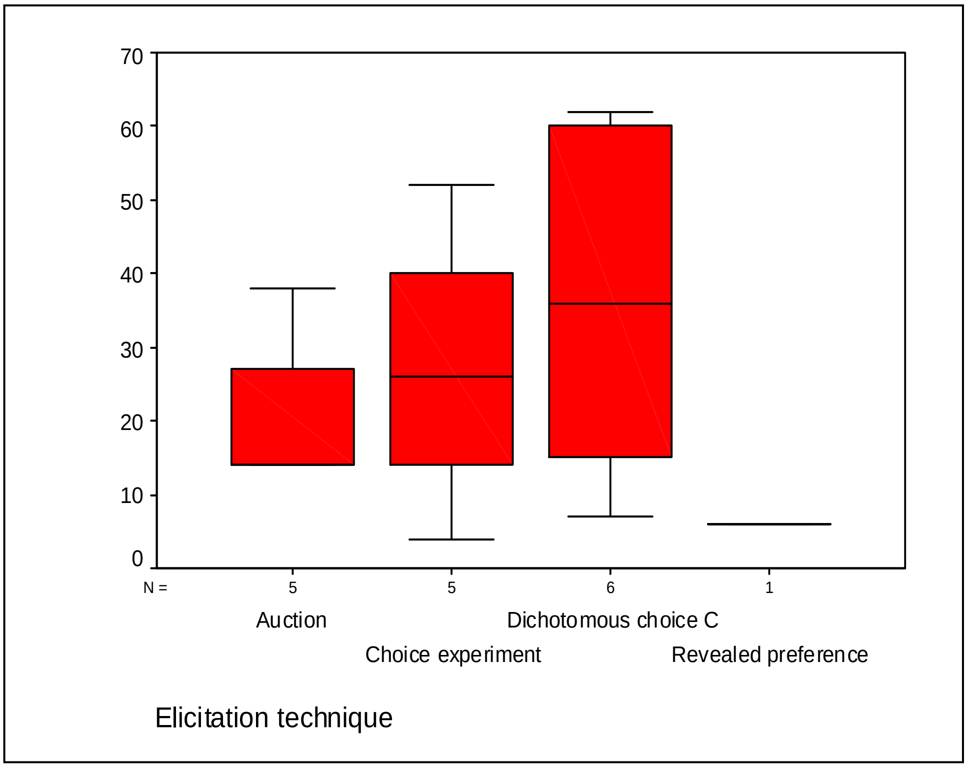

Figure 4.4: Boxplots of mean WTA GM without clear benefits by elicitation technique

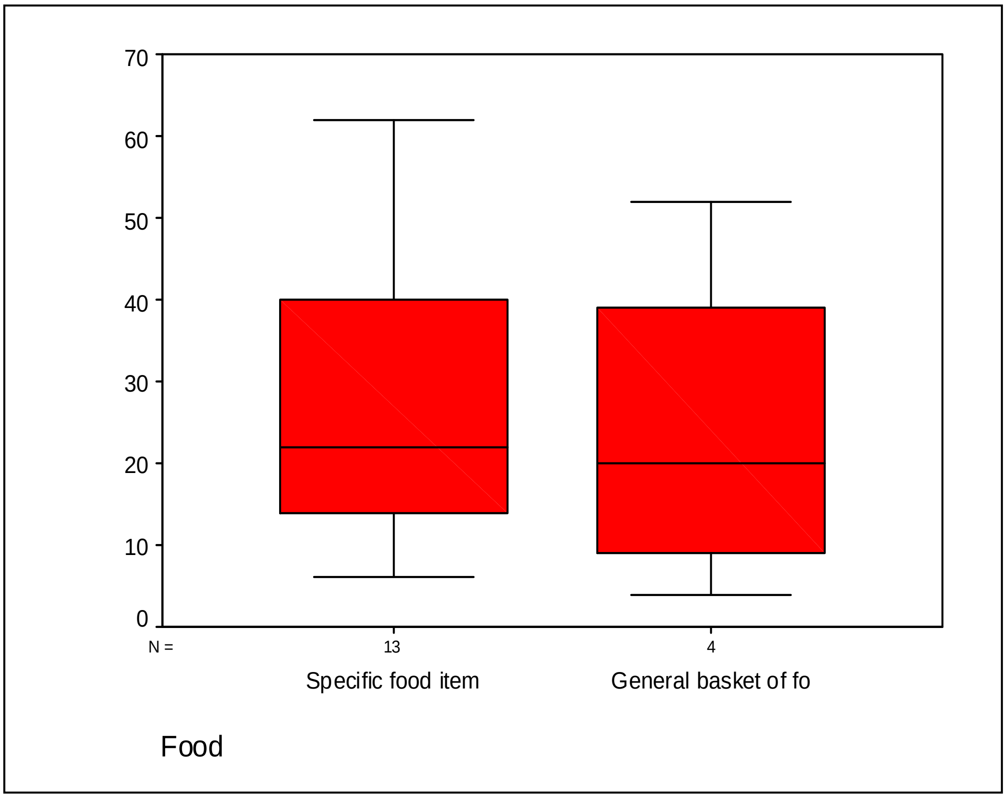

Figure 4.5: Boxplots of mean WTA GM without clear benefits by description of food in survey

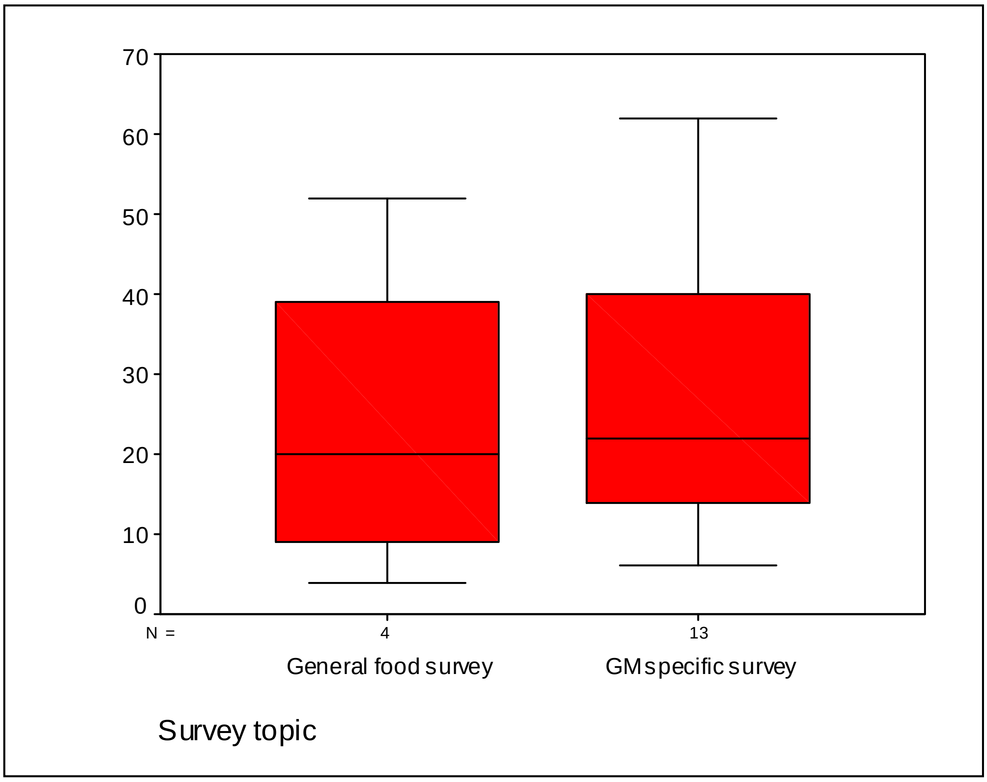

Figure 4.6: Boxplots of mean WTA GM without clear benefits by survey topic

WTP for GM-free

The results in table 4.7 show the number of observations, minimum and maximum values, standard deviation and mean WTP values for each category of each factor for the 'WTP for GM-free' data set. The 'WTP for GM-free' data set was the only one of the three where it was possible to evaluate the factor 'year of study' as it was the only one with results in both categories of the factor. Results suggest that studies carried out in '1998 or earlier' produced an average WTP that was lower than the average WTP from studies conducted in '1999 or later' (17% as opposed to 87%). As with the WTA dataset the 'country of study' factor shows a difference in values between the 'USA' and the 'rest of the world'. Specifically, the mean WTP value for the 'rest of the world' is higher than the 'USA' at 114% compared to 33%. The third of the cultural factors, 'participant group', also shows differences between categories. Specifically, the mean WTP value from the 'general population' is 107% ,compared to 29% and 79% for 'students' and 'shoppers' respectively. Regarding 'elicitation technique', 'choice experiments' produced the highest WTP value (132%). 'DC CV studies' produced the next highest WTP value (44%). 'Auction experiments' produced an average value lower than this (18%). The lowest mean WTP was from 'payment card method' (12%). Results show that 'auction experiments' yielded the same mean WTP value as 'open-ended questions'.

When considering the factor 'distribution method', it can be seen from table 4.7 that the highest mean WTP value arose from the category 'mail'. The second highest was from the category 'supermarket'. 'Telephone' and 'in-person studies' produced values of 38% and 27% respectively. The lowest value (19%) was from 'on-line surveys'.

The final two factors in this dataset were 'description of food in survey' and 'survey topic'. Surveys where respondents were asked about WTP for 'GM-free food in general' (that is on their whole food shopping) elicited an average WTP of 141%. This compares to 62% for surveys where a 'specific food item' was mentioned. The results for the factor 'survey topic' are similar. Results from the 'general food survey' category reveal a mean WTP of 125%, while the 'GM specific survey' category has a mean value of 65%. For illustrative purposes boxplots have been produced for all factors.

Table 4.7 WTP for GM-free

FACTOR	CATEGORY	NUMBER OF OBSERVATIONS	MIN VALUES	MAX VALUES	STANDARD DEVIATION	MEAN WTP
YEAR of study						
	1998 or earlier	3	13	23	5	17
	1999 or later	31	5	472	108	87
COUNTRY of study						
	Rest of the World	20	8	472	123	114
	USA	14	5	143	35	33
PARTICIPANT						
	Shoppers	4	5	194	81	79
	Students	10	10	62	18	29
	General population	20	8	472	125	107
ELICITATION technique						
	Auction	7	8	33	9	18
	Open-ended CV	2	16	20	3	18
	Choice experiment	18	13	472	123	132
	Payment card	3	5	19	7	12
	Dichotomous choice CV questions	4	19	62	20	44
DISTRIBUTION method						
	In-person	11	8	62	18	27
	Mail	11	12	472	142	168
	Supermarket	4	5	194	81	79
	Telephone	7	13	67	21	38
	On-line	1	19	19	-	19
GEN_OR_SPEC_food (Does survey deal with a general 'basket of food' or a specific food item?)*						
	General	8	13	472	174	141
	Specific	26	5	220	66	62
GEN_OR_SPEC_survey (Is survey a general food survey or GM specific?)						
	General survey	9	5	472	170	125
	GM specific	25	8	220	66	65

* No assumption was made about the impact of this variable on WTP values.

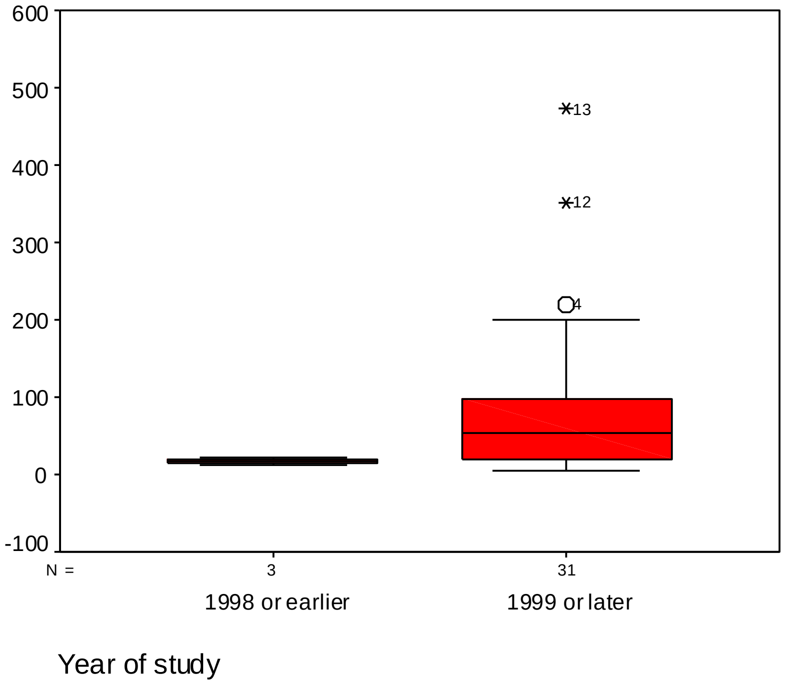

Figure 4.7: Boxplots of mean WTP for GM-free by year of study

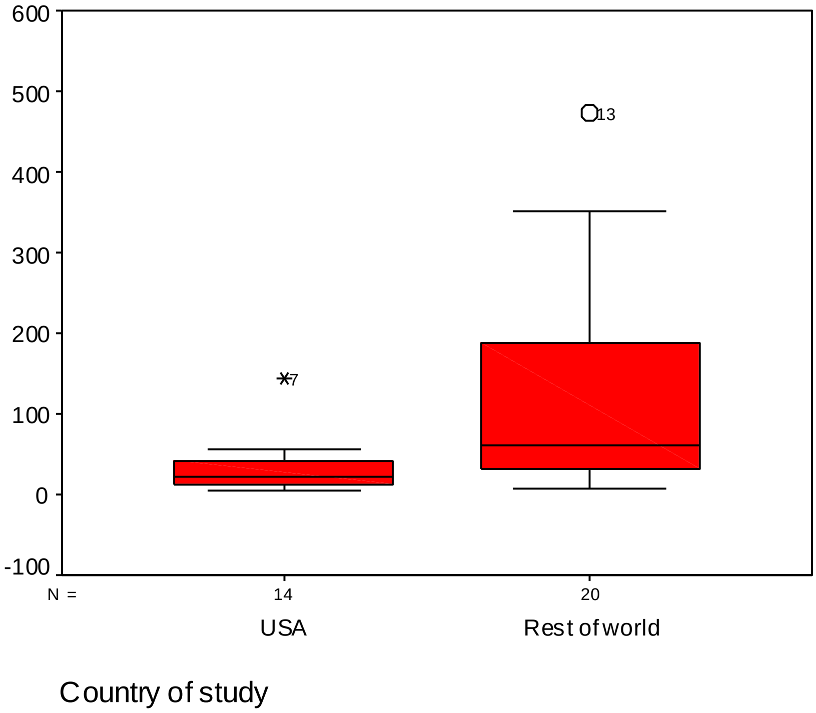

Figure 4.8: Boxplots of mean WTP for GM-free by country of study

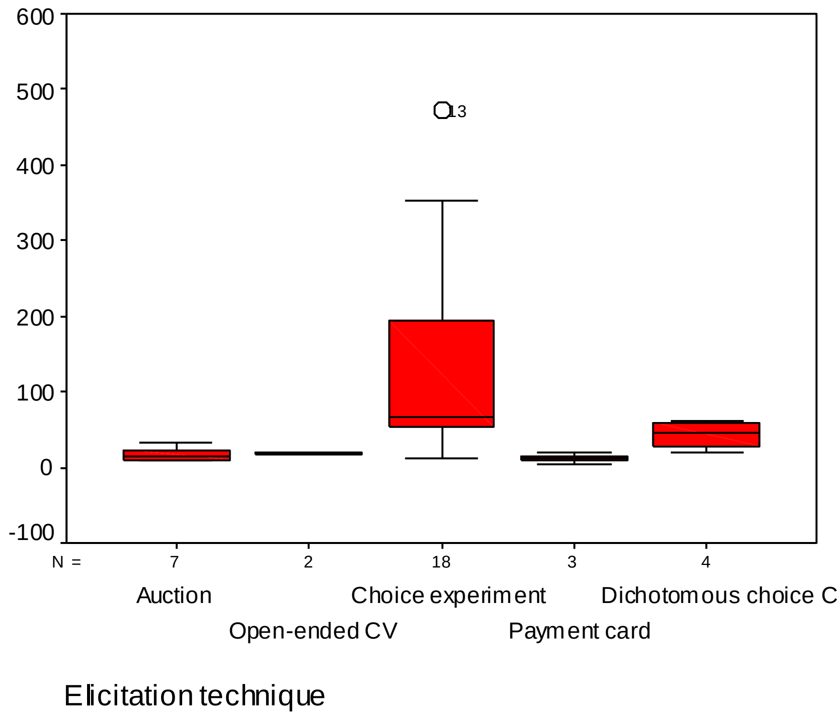

Figure 4.9: Boxplots of mean WTP for GM-free by elicitation technique

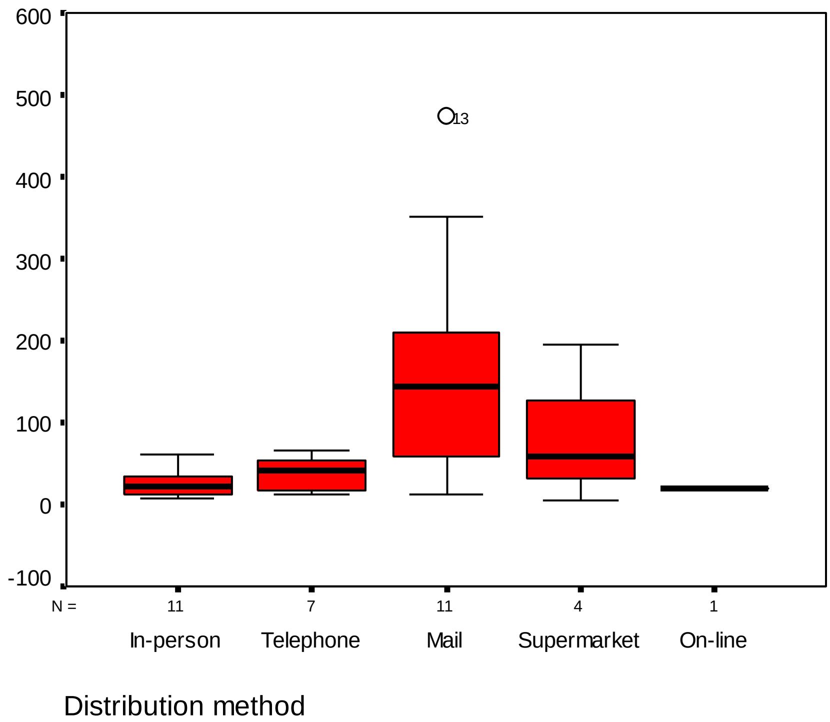

Figure 4.10: Boxplots of mean WTP for GM-free by distribution method

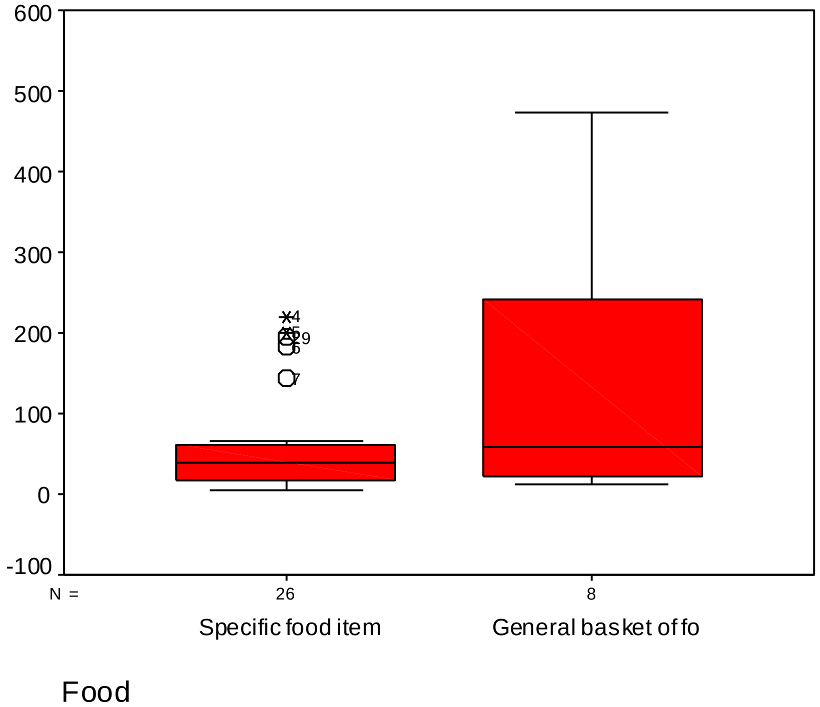

Figure 4.11: Boxplots of mean WTP for GM-free by description of food in survey

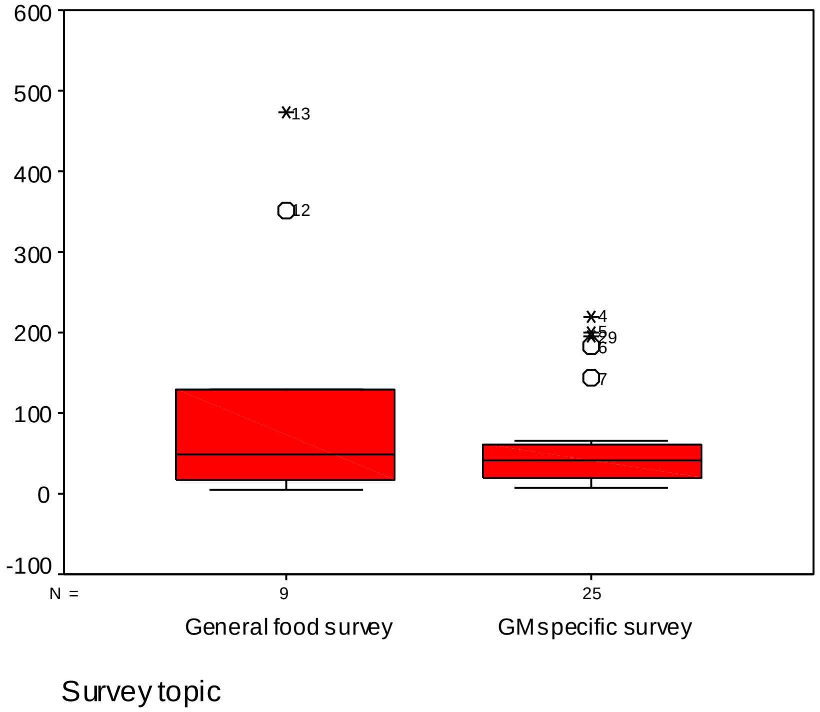

Figure 4.12: Boxplots of mean WTP for GM-free by survey topic

WTP for GM food with clear benefits

The results in table 4.8 show the number of observations, minimum and maximum values, standard deviation and mean WTP value for each category of each factor for the data set 'WTP for GM food with clear benefits'. The two cultural factors that could be examined in this dataset were the 'country of study' and the 'participant group'. Results show that the 'rest of the world' was WTP more than the 'USA', values being 13% and 9% respectively. Similarly, 'shoppers' were shown to be WTP more than the 'general population', with values of 14% to 9%. Within the factor 'elicitation technique' 'DC CV questions' demonstrated the highest WTP of 31%. Figures for 'payment card method' and 'revealed preference' were 4% and 5%, respectively. Results from the 'distribution method' factor show that the value for 'supermarket studies' was the highest at 14%, with 'mail surveys' at 11% and 'telephone' at 7%. The only other factor that could be examined under this dataset was that of 'description of food in survey'. This revealed that the value from studies where participants were presented with a 'specific food item' were higher, at 12%, than surveys where participants were asked about 'GM food generally', where values were 7%. Once more, for illustrative purposes box plots are produced for all factors.

Table 4.8 WTP for GM food with benefits

FACTOR	CATEGORY	NUMBER OF OBSERV-ATIONS	MIN VALUES	MAX VALUES	STANDARD DEVIATION	MEAN WTP FOR GM
COUNTRY of study						
	Rest of the World	6	5	38	13	13
	USA	10	0	43	14	9
PARTICIPANT						
	Shoppers	5	2	38	14	14
	General population	11	0	43	13	9
ELICITATION technique						
	Payment card	9	0	8	3	4
	Dichotomous choice CV questions	4	16	43	12	31
	Revealed preference in-store purchasing	3	2	8	3	5
DISTRIBUTION method						
	Telephone	4	5	8	2	7
	Mail	7	0	43	17	11
	Supermarket	5	2	38	14	14
GEN_OR_SPEC_food (Does survey deal with a general 'basket of food' or a specific food item?)						
	General	4	5	8	2	7
	Specific	12	0	43	15	12

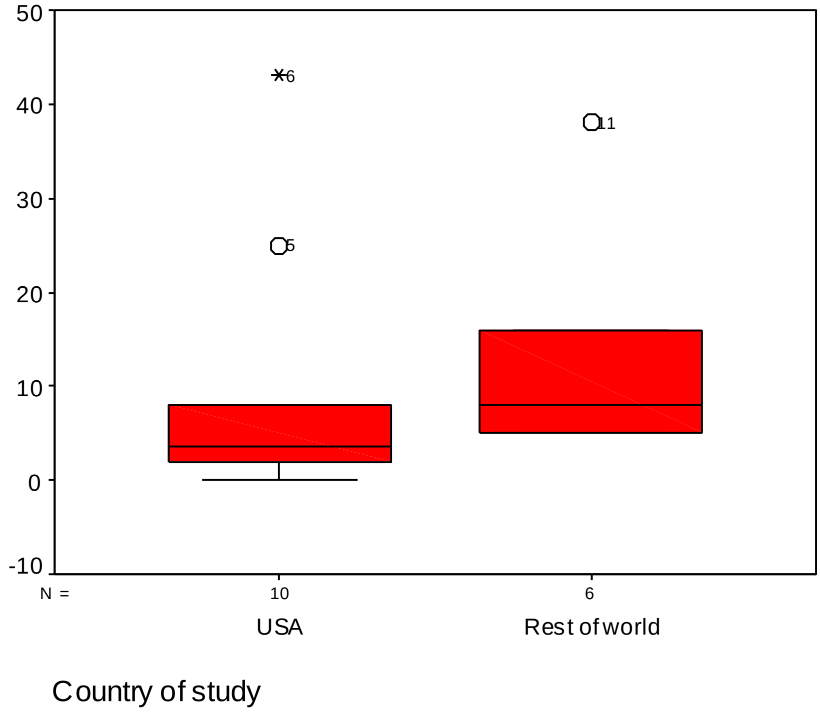

Figure 4.13: Boxplots of mean WTP for GM with benefits by country of study

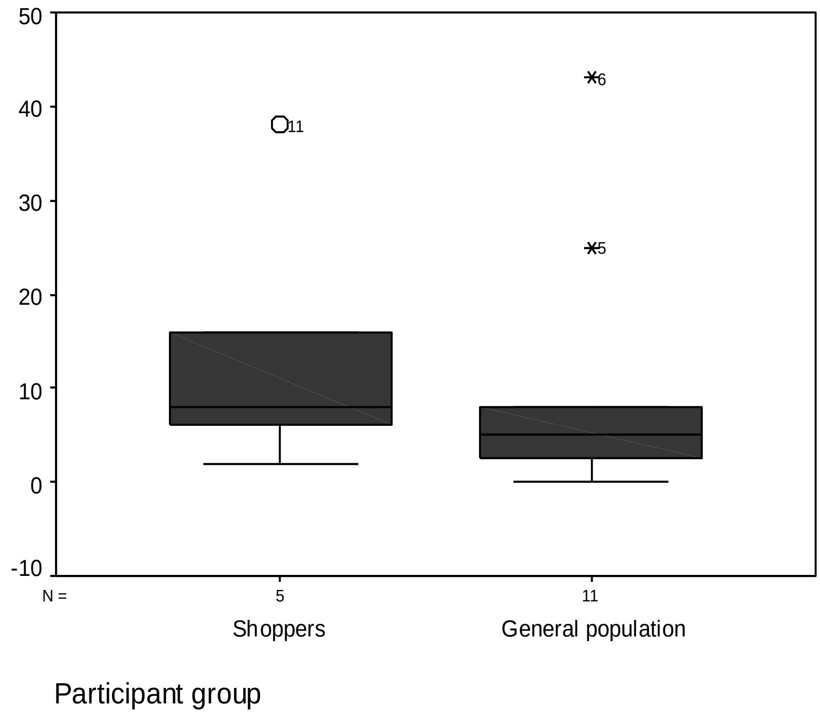

Figure 4.14: Boxplots of mean WTP for GM with benefits by participant group

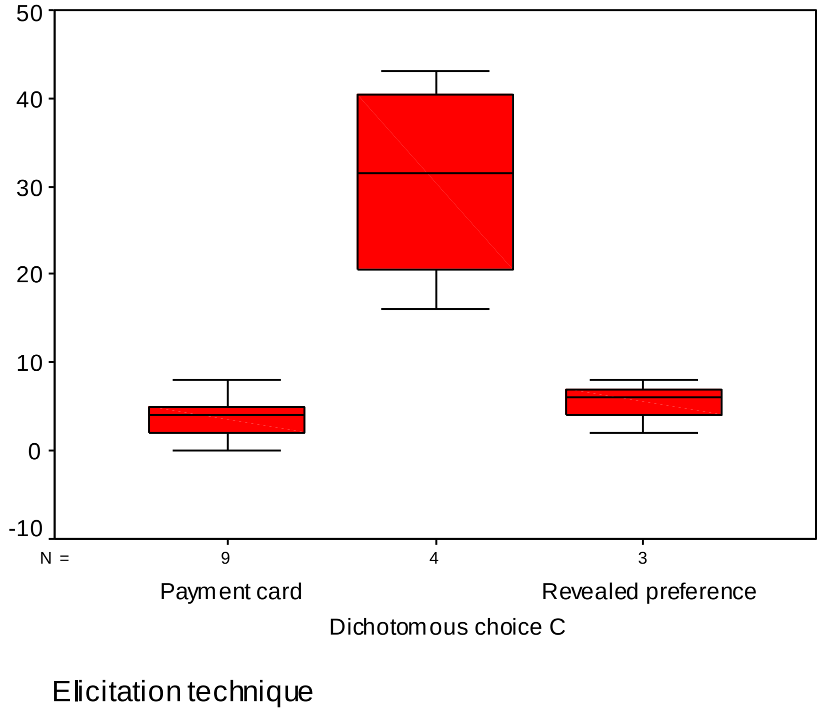

Figure 4.15: Boxplots of mean WTP for GM with benefits by elicitation technique

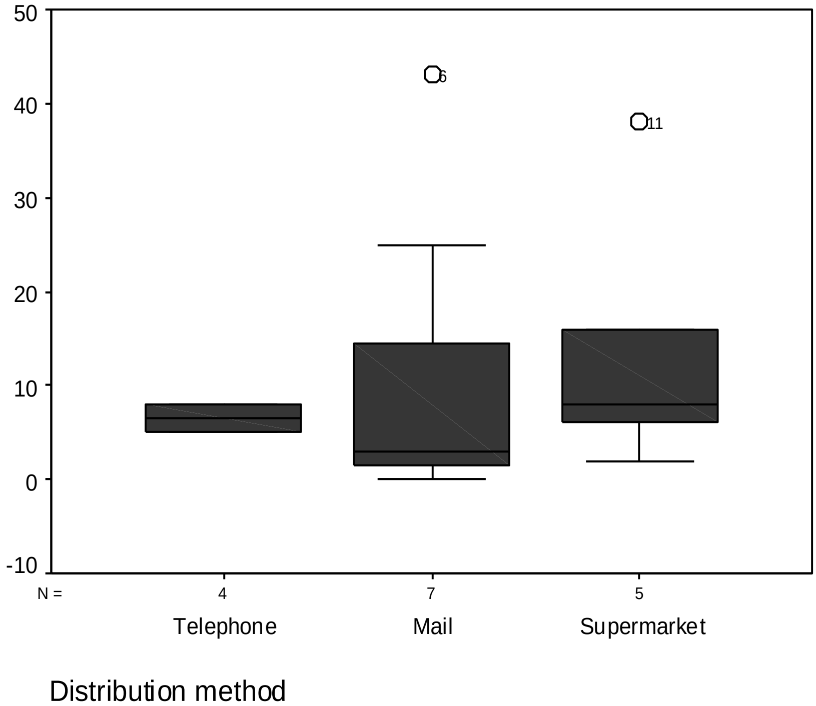

Figure 4.16: Boxplots of mean WTP for GM with benefits by distribution method

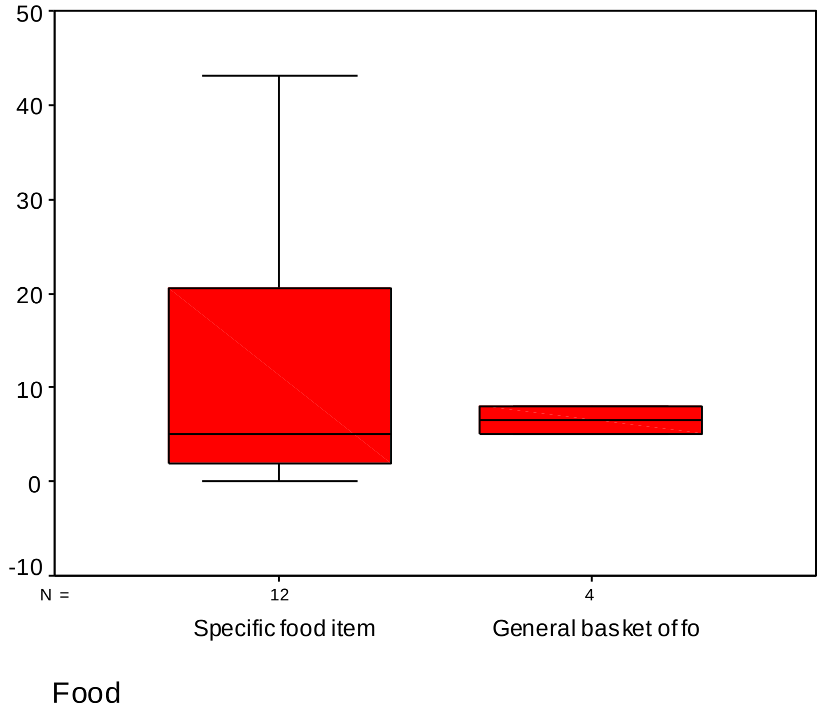

Figure 4.17: Boxplots of mean WTP for GM with benefits by description of food in survey

4.4.4 Results from T Tests and one way ANOVA

Descriptive statistical analysis is useful for initial examination of the data. However, in order to establish whether results were significant, further statistical analysis was conducted.

Comparing the three data sets

Descriptive statistics appeared to show that the three datasets produced different average values. The difference between the means of the three datasets was tested for statistical significance and found to be significant at the 99% level (f-statistic of 5.686, p-value of 0.005) (table 4.9).

Table 4.9 ANOVA WTP/WTA values

	SUM OF SQUARES	DF	MEAN SQUARE	F	SIG.
Between Groups	65493.994	2	32746.997	5.686	.005
Within Groups	368584.574	64	5759.134		
Total	434078.567	66			

Testing for significance of variables

Having carried out initial descriptive statistical analysis of the three data sets, means were compared using T tests and ANOVA to test for statistical significance of any differences in mean values. Tables 4.10, 4.11 and 4.12 present the results of the statistical analysis. As can be seen, only a small number of factors were found to have statistically significant differences between the means. These were, for the WTA dataset, the cultural factors ‘country of study’ (P value 0.022) and ‘participant group’ (P value 0.038). For the ‘WTP for GM-free’ dataset, the factors ‘country of study’ (P value 0.01), ‘elicitation technique’ (P value 0.039) and ‘distribution method’ (P value 0.008) were found to have statistically different mean values. For the ‘WTP for GM with benefits’ dataset, only ‘elicitation technique’ (P value 0.000) was found to have statistically significant different mean values.

Table 4.10 WTA statistical analysis – T tests and ANOVA

VARIABLE	MEAN VALUES				T-TEST STATISTIC	DEGREES OF FREEDOM	F STATISTIC	P-VALUE
Country of study					2.616	12	-	0.022*
	USA		ROW					
	16.5		37					
Participant group					2.281	15	-	0.038*
	Shopper		General population					
	44.5		22.1					
Food					0.386	15	-	0.705
	General basket		Specific item					
	24		28.38					
Survey					-0.386	15	-	0.705
	General food		GM specific					
	24		28.38					
Elicitation					-	-	0.959	0.441
	Auctio	Choice	DCCV	Revealed				
	21.4	27.2	36	6				
Distribution					-	-	2.436	0.124
	In-person	Mail	Supermarket					
	21.4	22.5	44.5					

* Significant at 0.05

Table 4.11 WTP GM-free statistical analysis – T tests and ANOVA

Variable	Mean values					T-test statistic	Degrees of freedom	F statistic	P-value
Year of study						-1.106	32	-	0.277
	1998 or earlier	1999 or after							
	17.3	87							
Country of study						-2.792	23.273	-	0.01*
	USA	ROW							
	32.9	114.3							
Food						-1.25	7.632	-	0.248
	General basket	Specific item							
	141	62.3							
Survey						1.046	8.899	-	0.323
	General food	GM specific							
	125.4	64.8							
Participant group						-	-	1.983	0.155
	Shopper	Gen. pop	Student						
	79	107.1	28.9						
Elicitation						-	-	2.911	0.039[#]
	OECV	Auc	Choic	DCCV	Pay				
	18	17.6	132.2	43.5	12				
Distribution						-	-	4.248	0.008*
	S'market	Pers	Onlin	Mail	Tel				
	79	27	19	168.4	37.7				

* Significant at 0.01
[#] Significant at 0.05

Table 4.12 WTP GM with benefits statistical analysis – T tests and ANOVA

Variable	Mean values			T-test statistic	Degrees of freedom	F statistic	P-value
Country of study				-0.566	14	-	0.58
	USA	ROW					
	9.4	13.3					
Participant group				0.628	14	-	0.54
	Shopper	General population					
	14	9.4					
Food				1.319	11.8	-	0.212
	General basket	Specific item					
	6.5	12.3					
Elicitation				-	-	24.97	0.000*
	Payment card	DCCV	Revealed				
	4	30.5	5.3				
Distribution				-	-	0.332	0.724
	Telephone	Mail	Supermarket				
	6.5	11.1	14				

* Significant at 0.01

4.4.5 Testing for interaction

One way ANOVA and T tests gave some indication of what was explaining mean values, however these analyses do not look for interaction between variables. Therefore, two way ANOVA was subsequently conducted in order to investigate this. During the one way ANOVA and T tests procedures, each independent variable was examined individually to assess its potential importance separately. In the two way ANOVA procedure those variables that were found to be significant in the one way ANOVA and T tests were retained and re-examined to explore any relationships between the variables. Given two variables, if both contain similar information, either one on its own may be important, whereas if either one is already included, the addition of the other may no longer add any extra information. Conversely if the two variables contain very different information it will be desirable to retain both. Two of the meta-analyses datasets (WTA GM and WTP for GM with benefits) contained less than 20 data points (cases) for the dependent variable (17 and 16 respectively). As this resulted in low values in many cells or indeed cells with no values, it was not feasible to test the one way ANOVA and T test results further.

WTP for GM-free

Having run T tests and ANOVA for the variables in the WTP for GM-free dataset, results suggested that three variables may be important. These were the ‘country of study’ variable, the ‘elicitation technique’ variable and the ‘distribution method’ variable (p values 0.01, 0.039 and 0.008 respectively). Next, two way ANOVA was run with pairs of these three variables in turn to investigate the questions “is there a ‘country’ by ‘elicitation technique’ interaction?”, or “a ‘country’ by ‘distribution method’ interaction?” or “an ‘elicitation technique’ by ‘distribution method’ interaction?”. For example, does ‘country’ have one effect on the values elicited by different elicitation techniques in the USA but a different effect on values elicited by studies conducted in countries in the rest of the world? Perhaps in the ‘rest of the world’ ‘DCCV’ studies elicit higher WTP values than ‘OECV’ studies, but in the USA ‘DCCV’ studies elicit lower WTP values than ‘OECV’ studies.

A potential problem was identified with both the ‘elicitation technique’ variable and the ‘distribution method’ variable. As both contained five or more levels there were missing values in a number of cells or low values in others. Hence the variables were re-coded to reduce the number of levels in each variable to four. This involved combining ‘supermarket’ and ‘online’ into one ‘other’ category in the ‘distribution method’ variable; and combining

‘OECV’, ‘payment card’ and ‘revealed preference’ in one ‘other’ category in the ‘elicitation technique’ variable.

Country of study by elicitation technique

Table 4.13 below displays descriptive statistics for each combination of factors in the model. There seems to be a country of study effect. On average, WTP values from USA studies are 33%, while values from studies conducted in the rest of the world are 114%. There also appears to be an elicitation technique effect. For example, on average, auction experiments elicit WTP values of 18% while choice experiment studies elicit WTP values of 132%. Lastly, there is some suggestion that there may be an interaction effect between ‘country of study’ and ‘elicitation technique’, because the mean differences in WTP values by ‘elicitation technique’ vary between ‘country of study’ in some cases. For example, ‘auction experiments’ in the USA have a higher WTP value than ‘other’ in the USA, but this trend is reversed in the rest of the world.

Table 4.13 Descriptive Statistics: Country of study by elicitation technique

COUNTRY OF STUDY	ELIC4CAT	MEAN	STD. DEVIATION	N
USA	Auction	19.1667	9.02035	6
	Choice experiment	79.0000	55.74944	3
	Dichotomous choice CV	56.0000	.	1
	Other	13.2500	6.39661	4
	Total	32.9286	35.44327	14
Rest of world	Auction	8.0000	.	1
	Choice experiment	142.8000	130.58506	15
	Dichotomous choice CV	39.3333	21.59475	3
	Other	19.0000	.	1
	Total	114.3500	123.35071	20
Total	Auction	17.5714	9.25306	7
	Choice experiment	132.1667	122.50486	18
	Dichotomous choice CV	43.5000	19.50214	4
	Other	14.4000	6.10737	5
	Total	80.8235	104.44934	34

In this case it is also useful to examine a profile plot of the estimated marginal means. Figure 4.18 is a visual representation of the estimated marginal means. The factor levels of elicitation technique are shown along the horizontal axis. Separate lines are produced for each level of country of study. If there is no interaction between factors the lines in the profile plot should be largely parallel. In this case it can be seen that the lines intersect, suggesting there may actually be some interaction.

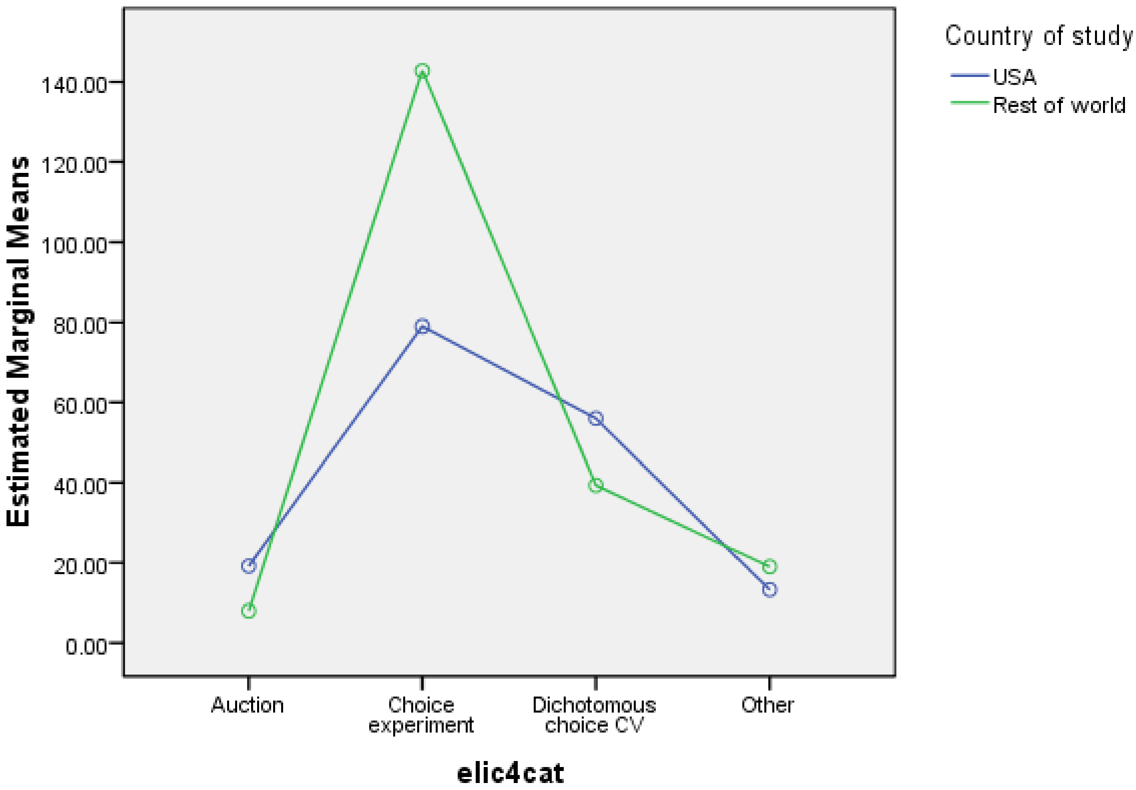

Figure 4.18 Estimated marginal means of WTP (%) (country/elicitation)

However, running two way ANOVA suggested there was no interaction between 'country of study' and 'elicitation technique' (p value 0.878). Thus respondents in the USA and respondents in countries in the rest of the world can be assumed to react to the different kinds of environmental economics survey tools in a similar way. One of the assumptions of this test is that there is homogeneity of variance of the error term across levels in independent variables (Garson, 2009). In this case Levene's test of equality of variances is non-significant at the 0.01 level, which shows that the error variance of the dependent variable is equal across the groups, i.e. the assumption of the ANOVA test has been met.

Country of study by distribution method

Table 4.14 below displays descriptive statistics for each combination of factors in the model. There seems to be a 'country of study' effect. On average, WTP values from USA studies are 33%, while values from studies conducted in the rest of the world are 114%.

There also appears to be a distribution method effect. For example, on average, in-person studies elicit WTP values of 27% while studies by mail elicit WTP values of 168%. Lastly, there is some suggestion that there may be an interaction effect between 'country of study' and 'distribution method', because the mean differences in WTP values by 'distribution method' vary between 'country of study' in some cases. For example, 'in person studies' in the USA have a higher WTP value than 'other' in the USA, but this trend is reversed in the rest of the world.

Table 4.14 Descriptive Statistics: Country of study by distribution method

COUNTRY OF STUDY	DIST4CAT	MEAN	STD. DEVIATION	N
USA	In-person	24.4286	16.17464	7
	Telephone	32.5000	17.52142	4
	Mail	77.5000	92.63099	2
	Other	5.0000	.	1
	Total	32.9286	35.44327	14
Rest of world	In-person	31.5000	23.58672	4
	Telephone	44.6667	28.18392	3
	Mail	188.5556	146.86993	9
	Other	82.5000	76.65725	4
	Total	114.3500	123.35071	20
Total	In-person	27.0000	18.34666	11
	Telephone	37.7143	21.46093	7
	Mail	168.3636	141.89029	11
	Other	67.0000	74.88992	5
	Total	80.8235	104.44934	34

However, the profile plot of the estimated marginal means shows two almost parallel lines, which might suggest it is unlikely that there is an interaction effect between 'country of study' and 'distribution method' (figure 4.19). It is worth noting, however, that the plot does show that the difference between in-person and mail studies, and between telephone and mail studies, appears to be greater in the rest of the world than in the USA since the line is steeper for the rest of the world.

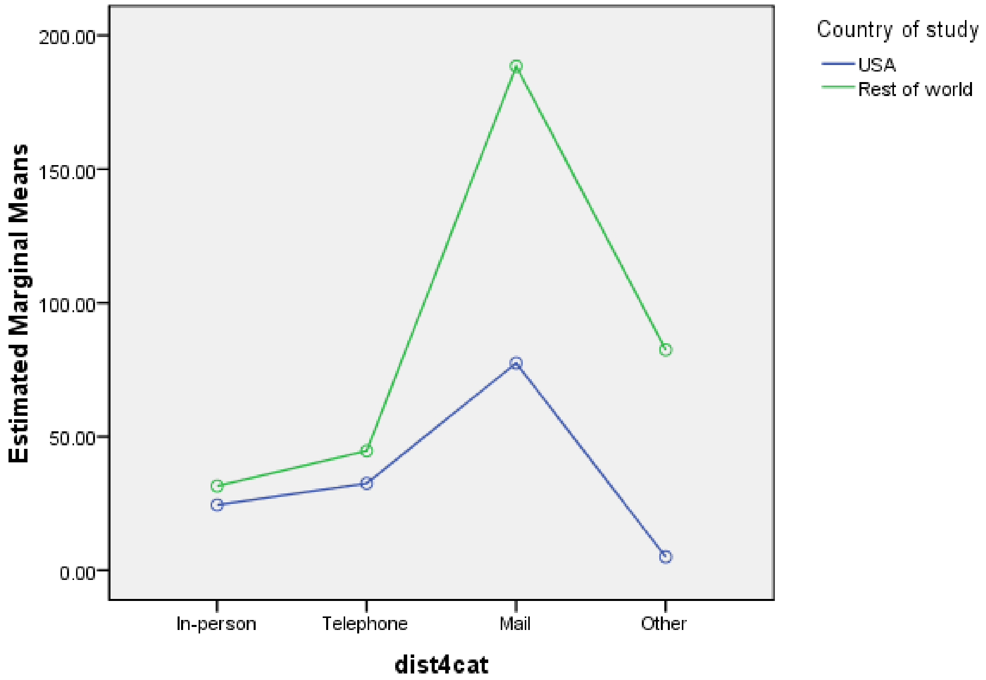

Figure 4.19: Estimated marginal means of WTP (%) (country/distribution)

On its own the marginal means plot does not confirm one way or the other whether there is any statistically significant interaction between the factors. However, running two way ANOVA suggested that actually there was no interaction between 'country of study' and 'distribution method' (p value 0.640). Thus results suggest that respondents from the USA do not react differently to people in countries in the rest of the world to different ways of conducting surveys. Levene's test of equality of error variances is non-significant at the 0.01 level, confirming that the error variance of the dependent variable is equal across groups and that the ANOVA results can therefore be treated as valid.

Distribution method by elicitation technique

Table 4.15 below displays descriptive statistics for each combination of factors in the model. There seems to be an 'elicitation technique' effect. For example, on average, auction experiments elicit WTP values of 18%, while choice experiment studies elicit WTP values of 132%. There also appears to be a 'distribution method' effect. For example, on average, in-person studies elicit WTP values of 27% while studies by mail elicit WTP values of 168%. Lastly, there is no suggestion that there may be an interaction effect between 'elicitation technique' and 'distribution method', because the mean differences in WTP values by 'distribution method' do not vary between 'elicitation technique'. For example, choice experiments conducted by telephone, mail and other distribution methods always appear to elicit higher WTP values than other elicitation techniques conducted using the same distribution methods.

Table 4.15 Descriptive Statistics: Distribution method by elicitation technique

DIST4CAT	ELIC4CAT	MEAN	STD. DEVIATION	N
In-person	Auction	17.5714	9.25306	7
	Dichotomous choice CV	43.5000	19.50214	4
	Total	27.0000	18.34666	11
Telephone	Choice experiment	45.6000	20.41568	5
	Other	18.0000	2.82843	2
	Total	37.7143	21.46093	7
Mail	Choice experiment	184.0000	139.21766	10
	Other	12.0000	.	1
	Total	168.3636	141.89029	11
Other	Choice experiment	103.6667	78.27090	3
	Other	12.0000	9.89949	2
	Total	67.0000	74.88992	5
Total	Auction	17.5714	9.25306	7
	Choice experiment	132.1667	122.50486	18
	Dichotomous choice CV	43.5000	19.50214	4
	Other	14.4000	6.10737	5
	Total	80.8235	104.44934	34

In this case the estimated marginal means profile plot is not particularly helpful due to missing cell values in the data. Hence, although the plot shows two non-parallel lines, if there were adequate data in all cells there would be four lines which would be much more informative (figure 4.20).

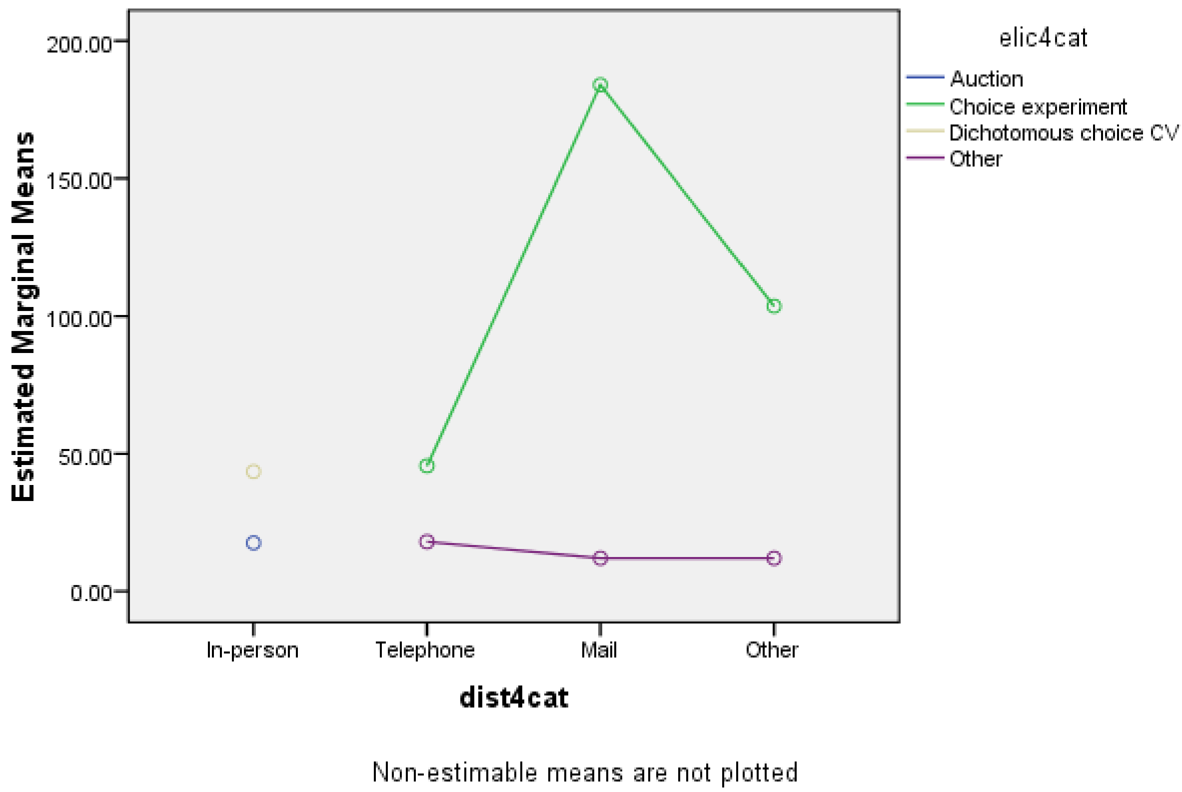

Figure 4.20 Estimated marginal means of WTP (%) (distribution/elicitation)

The two way ANOVA test confirms the lack of an interaction effect between 'distribution method' and 'elicitation technique' (p value 0.462). Levene's test of equality of error variances is non-significant at the 0.01 level, confirming that the error variance of the dependent variable is equal across groups and that the ANOVA results can therefore be treated as valid.

4.5 Discussion

4.5.1 WTA GM

The initial descriptive statistical analysis suggested that there were differences between mean values for a number of the factors in the 'WTA GM' meta-analysis. However, only two of the factors were found to have statistically significant differences between means. These were 'country of study' and 'participant group'. The results suggest that consumers outside the USA may require a greater discount before accepting GM food products, and supports the assumption made about this factor. The results from the analysis of the 'participant group' suggest that when in a real shopping environment people are more directly connected to the issue of food expenditure and hence more likely to require larger reductions. Importantly, both of these results suggest that cultural setting may be significant in affecting contingent values. Overall, the results from this dataset suggest that the cultural factors may be more important than the question format/study design factors, for influencing contingent values.

4.5.2 WTP GM-free

Again the initial descriptive statistical analysis for the 'WTP for GM-free' dataset, suggested that a number of the factors might be important in influencing the values. However, there were only three factors for the 'WTP for GM-free' dataset, where the differences between means were shown to be statistically different. These were 'country of study', 'elicitation technique' and 'distribution method'. The 'country of study' factor shows a difference in values between the 'USA' and the 'rest of the world'. Specifically, the mean WTP value for the 'rest of the world' is higher than the 'USA' at 114% compared to 33%. Regarding 'elicitation technique', 'choice experiments' produced by far the highest WTP value (132%). 'DC CV studies' produced the next highest WTP value, as predicted (44%). 'Auction experiments' produced an average value lower than this (18%), again as predicted. However, the lowest mean WTP was not from 'open-ended CV questions' (mean WTP 18%) but from 'payment card method' (12%). Results show that 'auction experiments' yielded the same mean WTP value as 'open-ended questions', which is not as expected. However, it should be noted that results for the categories 'open-ended CV questions' and 'payment card method' were based on only two and three observations respectively. As noted, 'choice experiments' elicited the highest average values. It is suggested that an area where more research would be useful is the effect of choice experiments on WTP values. When considering the factor 'distribution method' by far the highest mean WTP value arose from the category 'mail'. This is in line with previous studies and thus supports the assumption made earlier. The second highest was from the category 'supermarket' although this was based on only four observations. 'Telephone' and 'in-person studies' produced values of 38% and 27% respectively. The lowest value (19%) was from 'on-line surveys' but this was based on only one observation.

Analysis aiming to investigate interaction between pairs of the three significant variables, 'country of study', 'elicitation technique' and 'distribution method', failed to reveal any interaction, although given missing values and low cell values, some of these results should be treated with caution. For example, it is possible that, given a larger dataset, interaction would have been revealed between 'country of study' and 'elicitation technique', meaning that respondents in the USA may actually react differently to different environmental economics survey tools than respondents from countries in the rest of the world. However, this has not been proven here.

Overall, the results from this dataset suggest that the ‘question format’ factors may be more important than the ‘cultural factors’ in influencing values. It should also be noted that this dataset contained more observations overall than the other two datasets, suggesting that these results are likely to be more robust.

4.5.3 WTP GM with benefits

There was only one factor in the ‘WTP for GM with benefits’ dataset, ‘elicitation technique’, that was found to have statistically significant different mean values. The most notable result from this dataset is that within the factor ‘elicitation technique’ ‘DC CV questions’ again demonstrated the highest WTP of 31%. Figures for ‘payment card method’ and ‘revealed preference’ were only 4% and 5%, respectively. Overall, it is difficult to draw any firm conclusions from these results as there were so few observations in many of the categories of the factors under consideration. Nevertheless, as with the other two datasets, it is possible to conclude that one of the variables, in this case ‘elicitation technique’, does affect values. As this is the only variable found to be statistically significant, it suggests that the cultural factors are not as important as the question format/study design factors, in this case.

4.5.4 Which factors are important?

From the foregoing analysis, it is apparent that there are some messages emerging. First, cultural factors appear to be important. The ‘country of study’ variable looks to be important, with values lower in the ‘USA’ than the ‘rest of the world’. Also significant for one of the datasets was ‘participant group’, where ‘shoppers’ expressed a higher WTA than the ‘general population’.

There are also some common messages about question format factors, in terms of ‘elicitation technique’ and ‘distribution method’. It is notable that ‘DC CV questions’, in line with previous studies, produce highest WTP values, with the exception of ‘choice experiment’ results in one of the datasets. However, research needs to be conducted on the impact of choice experiment format on WTP values. It is worth noting here that choice experiments are both difficult to design and challenging for respondents to complete. These two issues may create ‘problematic’ results. Hence there is uncertainty about the impact on WTP values of choice experiment methodology, and inconsistency of results. Also, the fact that the datasets included studies that used a number of other techniques, such as 'revealed preference in-store purchasing' and 'payment card method', made the results less clear, particularly because of the small numbers of studies using these approaches. The effect of different distribution methods is also unclear. 'Mail surveys' produced the highest values, but 'supermarket surveys' also produced higher values. However, this finding was statistically significant for only one of the data sets. Additionally, assumptions about 'in-person studies' and 'telephone studies' were not supported by the results in all cases.

Results relating to the effect on mean values of the 'description of food in the survey' and the 'survey topic' are largely inconclusive.

It is possible to conclude that both groups of factors, cultural factors and question format factors, influence values, to some extent. However, consistent messages are hard to discover through such a diverse group of studies. Also, the small numbers of observations in some categories of some variables may have limited the derivation of significant results.

4.5.5 What do the contingent values measure?

The question of interest here is what is being measured by the WTP/WTA values in the above meta-analyses? It is widely acknowledged in the environmental economics literature that researchers do not know what drives responses in contingent valuation studies (Wang & Rolfe, 2009) thus, to a certain extent, there is always uncertainty surrounding the question of what is being measured by WTP/WTA values. What is of relevance to the thesis is the extent to which they can be said to measure perceptions of risk. As noted in the introductory section of this chapter, contingent values are derived from the utility function. It is reasonable to assume that a component of the utility function in these WTP/WTA studies relating to GM food is the perception of risk that people associate with the food under consideration. Wang and Rolfe (2009) note that where non-market valuation studies are dealing with a topic around which there is a large degree of uncertainty, this will impact on the risk perceptions of people which in turn will lead to "preference uncertainty" and this inherent uncertainty can be expected to play a large role in value estimates.

In many of the 25 studies included in the meta-analyses, the authors refer explicitly to the inclusion of perceptions of risk in their studies (see for example, Lusk *et al*, 2003; Mendenhall & Evenson, 2002; Lusk *et al*, 2001; Moon & Balasubramanian, 2003; Baker & Mazzocco, 2002; Chen & Chern, 2004; McCluskey *et al*, 2003; Grimsrud *et al*, 2004; Li *et al*, 2002). More importantly, where the relationship between perceptions of risk and WTP/WTA values was examined, results suggested they were positively correlated (Lusk *et* *al*, 2003; Mendenhall & Evenson, 2002; Lusk *et al*, 2001; Moon & Balasubramanian, 2003; Chen & Chern, 2004; McCluskey *et al*, 2003; Loureiro & Bugbee, 2005), and often strongly so. Although not included within the meta-analyses, Kaneko and Chern (2005) also found that risk perception significantly affected the non-GM premium that people were willing to pay. It is reasonable to claim therefore that many WTP values are measuring, to some extent, perceptions of risk associated with GM foods.

In light of this, it is of interest to look again at the values derived. Both the mean 'WTA GM' value and the mean 'WTP for GM-free' value are higher than the mean 'WTP for GM with benefits' value, suggesting that, so far, the perceived risks of GM food outweigh the promised benefits (in the minds of some consumers). Given the comments in the section above, the 'WTA GM' value of 27% could be interpreted as the value of risk associated with GM. However, the 'WTP for GM-free' figure is perhaps even more significant as this suggests that people perceive the risks to be so great that they are WTP 81% extra to avoid them. This could also be interpreted as the value of risk that GM food is perceived to present. Overall, it may be useful to consider the value of risk as being in a range between 27% and 81% of existing food prices.

In addition, the results from the meta-analyses about the factors influencing the values obtained can, by inference, be said to be related to perceptions of risk.

4.6 Conclusions

4.6.1 Key findings – Value of risk (and benefit)

The work presented in this chapter has provided a useful systematic collation and examination of a total of 25 studies containing 67 values relating to the valuation of GM food. The first key result from this analysis was the realisation that in fact there were three separate data sets from the studies, based on how the question was posed. This made it possible to derive three values representing different aspects relating to GM food, in the minds of consumers. The first step was to compare the three datasets and compare the values deriving from each. Key findings from the comparison of means are, first, that the mean 'WTP for GM-free food' (in other words, to keep consuming conventional food and avoid the GM equivalent) is 81% above existing food prices. Second, 'WTA GM food without clear benefits', occurs at a mean price reduction of 27% less than existing conventional food prices. Third, 'WTP for GM food with benefits' is 11% above existing conventional food prices. The latter suggests that some GM food might be acceptable to some consumers if it has clear benefits. Nevertheless this is far less than the other two values, both of which can be said to represent the value of GM food when it is presented as new, unknown and potentially risky. Overall, the conclusion is that the value that consumers are willing to pay to avoid GM food lies between 27% and 81% of conventional product prices, and that this value implicitly represents the value of risk that people perceive GM food to present.

4.6.2 Cultural factors and question design factors

Although it is hard to draw consistent messages from the results, it is possible to conclude that there are variables within both groups of factors that have been shown to influence how much people are willing to pay to avoid GM food, and that therefore are related to perceptions of risk.

4.6.3 Next chapter

In the chapter that follows, a study is reported that has examined risk perceptions much more narrowly, through focusing on a specific segment of the population within Scotland. The study also allowed the investigation of more of the factors identified in chapter three as influencing risk perceptions. These include the relationship between perceived risk and perceived benefit, the impact of environmental values, socio-demographic characteristics and cultural factors, and some of the psychometric paradigm dimensions of risk, such as issues of control over exposure, unpredictability of impacts, and equity or distribution of impacts.

Chapter 5: Survey of anti-GM and environmental campaign group members[5]

5.1 Introduction

5.1.1 Aims of this chapter

The aim of the research presented in this chapter was to investigate the views of anti-GM and environmental campaign group members, specifically, their perceptions of the risks and benefits associated with GM food. In order to achieve this aim, the objective was to carry out a postal survey with the targeted population in Scotland. This specific population – members of anti-GM campaign groups and environmental non-governmental organisations (NGOs) in Scotland - were chosen as they can be expected to represent the population with the greatest level of risk perception when considering the issue of GM food.

One aim of the survey was to test the relationship between perceived risk and perceived benefit. In addition, the intention was to investigate the impact on risk perceptions of environmental values, trust, and a number of socio-demographic characteristics and cultural factors. Also, some of the psychometric paradigm dimensions of risk were investigated. Thus the survey addressed issues of control over exposure, unpredictability of impacts, and equity or distribution of impacts. These were selected as they have been identified in the literature relating to the GM debate, as most pertinent to the rejection or acceptance of the technology.

The chapter begins with a brief reminder of the nature of consumer concerns relating to GM foods. Next, consideration is given to the role of campaigners in resistance to GM foods, and the nature of anti-GM activities. Also addressed in a review of literature, is investigation of environmental attitudes, and the claims that have been made about the future risks and benefits of GM food. A description of the survey methodology follows. The remainder of the chapter contains the presentation and discussion of results, and conclusions.

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[5] Note that a version of this chapter has been published in Journal of Rural Studies (http://www.sciencedirect.com/science?_ob=MImg&_imagekey=B6VD9-4GJKTRW-1-1&_cdi=5977&_user=616403&_pii=S0743016705000458&_origin=browse&_zone=rslt_list_item&_coverDate=01%2F31%2F2006&_sk=999779998&wchp=dGLzVzb-zSkzk&md5=00cca8bcc5e1e29ea19d9ebc7263ccbd&ie=/sdarticle.pdf)

5.2 Background to the survey

5.2.1 GM technology and consumer concerns

Since the widespread introduction of GM food and crops in some countries, a large number of studies have investigated consumer attitudes to the technology, and surveys and polls continue to point to consumer opposition to GM food (see for example, DEFRA (2002); MORI (2003); Gaskell *et al* (2006)). As discussed in chapter two, previous studies have revealed a diversity of consumer concerns relating to GM food, including unpredictable health risks (Lemkow, 1993; Olubobokun & Phillips, 2004; Isaacs, 2001; Subrahmanyan & Cheng, 2000; Verdurme & Viaene, 2003), environmental safety risks (Olubobokun & Phillips, 2004; Isaacs, 2001), and the structure of agri-business (Isaacs, 2001). There are fears that there may be long-term environmental effects (Lemkow, 1993), risks to future generations (Poortinga & Pidgeon, 2003; Rosati & Saba, 2000), and long-term food safety issues (Grove-White *et al*, 1997). These long-term effects are expected in many instances to be largely unpredictable.

5.2.2 Anti-GM activities

Most previous studies have investigated the concerns of the general population towards genetic engineering. However, in many media reports of opposition to GM foods, particular emphasis has been placed on the role of anti-GM campaign groups and environmental action groups such as Greenpeace and Friends of the Earth. This section of society has been dismissed as being an irrational minority and their views discounted[6], yet there is currently a gap in the understanding of their perceptions of risk relating to GM. Where this study differs from much of the earlier work, is in targeting anti-GM campaigners and environment group members who have been vocal in their opposition to adoption of the technology.

There have been a small number of studies that have emphasised the role of environmental action groups in the anti-GM debate. Purdue (2000) examined the role of anti-GM campaign groups in the UK in some depth. Although he refers to the role of small, single issue NGOs, such as Genetics Forum, he also emphasises the significance to the anti-GM debate, of large membership NGOs such as Greenpeace. Environmental organisations are recognised as being predominant in the campaign against GM food, with groups such as

[6] See for example the report from GM Nation? (http://www.gmnation.org.uk/docs/gmnation_finalreport.pdf) which places at least as much emphasis on the results from 10 discussion groups involving a total of 77 people as it does on the results from public meetings attended by an estimated 20,000 people, and from 36,000 feedback forms.

Friends of the Earth and Greenpeace taking public positions against GM technology in agriculture (Reisner, 2001).

A range of ‘anti-GM’ activities has taken place in Scotland in recent years, underlining the significance of anti-GM sentiment, and the need to understand the motivations of those involved in such activities. First, there was a long-running anti-GM campaign against crop trials that took place in the Black Isle. As reported in the Guardian “*... under cover of darkness, someone entered the field at Roskill Farm and ripped out some five acres of plants. And... five people were arrested after tearing up more plants*” (Scott, 2002).

Further, in 2002 a petition was submitted to the Scottish Parliament Health and Community Care committee, demanding (among other things), an end to the GM field trials on the grounds of potential health risks. This was signed by 6500 people.

In June 2003, many Scottish residents were also actively involved in the government-sponsored GM-Nation debate. As well as the official ‘tier one’ meeting organised in Glasgow, there were many other local meetings held throughout the country. In the GM-Nation final report, 48 meetings with 30 or more attendees, are listed as having taken place in 11 regions in Scotland, involving at least 1440 people in total (Heller, 2003). It is reasonable to suggest that people who could be termed ‘anti-GM’ campaigners because of their membership of specific groups (environmental or anti-GM) may have been involved in at least some of these activities.

5.2.3 Measuring environmental attitude

As much of the resistance to GM foods is from environmental groups, and as general attitudes to the environment have been shown to influence perceptions of risk relating to GM food, an understanding of the environmental values of acceptors and non-acceptors of GM products may be useful (Isaacs, 2001). An individual’s views about the environment may influence their risk perceptions and thereby contribute to willingness (or unwillingness) to accept GM food, as discussed in chapter three. As GM food is alleged to have both positive environmental effects (for example, reduced pesticide use), as well as negative impacts (for example, impact on non-target species), an ‘environmentalist’ may accept or reject GM technologies depending on which element of their environmental concerns is stronger.

The New Ecological Paradigm (NEP) scale (Dunlap *et al*, 2000) was developed to examine environmental values, and has been used in previous studies into consumer attitudes to the risks of GM food (Poortinga & Pidgeon, 2003; Isaacs, 2001). The NEP scale is generally considered to measure an overall worldview and has been found to have an acceptable level of internal consistency using Cronbach's Alpha reliability coefficient (Cronbach, 1951). However, as measures of reliability depend as much on the survey sample as on the survey instrument, it is not correct to state that a pre-existing scale is reliable, just because it has been found to be so in previous studies (Streiner, 2003). Cronbach's Alpha reliability coefficient normally ranges between 0 and 1, and the closer the coefficient value is to 1.0, the greater the internal consistency of the items in the scale (Gliem & Gliem, 2003). Put simply, an estimate of 0.70 indicates that the scale results are 70% reliable (Brown, 1997).

The question of how many dimensions the NEP scale includes is subject to debate. The original scale contained 12 items and was considered by the authors to demonstrate three major facets of environmental belief – 'balance of nature', 'limits to growth' and 'human dominance over nature'. Other authors variously found that the 12 item scale contained a single factor, or two, three or four dimensions (see Dunlap *et al*, 2000). Further, even where three dimensions were identified these have not always correlated with the three facets of environmental belief that the scale was originally believed to measure. The authors note therefore that the facets of the scale are generally study-specific. Further, the NEP scale was revised in 1990, some statements were re-written and an additional three statements were added to address two additional facets of environmental concern – the idea that humans, unlike other species, are exempt from the constraints of nature (termed 'exemptionalism'), and the threat of an eco-crisis. Thus, the updated NEP scale claimed to measure five dimensions of environmental beliefs that constituted peoples' overall environmental worldview. In a study reported in 2000 (Dunlap *et al*) it was shown to have a co-efficient alpha value of 0.83.

5.2.4 Future benefits and risks

In chapter two there was a description of the types of genetic modifications that have been commercialised so far, and reference was made to some of the claims about potential future modifications. Here, this latter issue is addressed in greater detail. There have been various claims made in the literature regarding the future risks and benefits that will be presented by further developments of GM technology, or the introduction of current GM technologies to countries not yet growing GM crops commercially.

The range of benefits that it is claimed future technologies will offer can be categorised under the headings of health, social, consumer, economic and environmental. For example, health benefits will (it is claimed) be gained from fruit and vegetables genetically engineered to contain higher levels of vitamins, such as C and E (Frewer *et al*, 1999). Rice has been developed to contain higher levels of vitamin A (Pretty, 2001). In addition, pharmaceutical developments may lead to potatoes (for example) which contain a vaccine for hepatitis b (Pretty, 2001). Other health benefits will arise (it is claimed) from the development of GM crops engineered to modify starch and oil content, leading to legumes and oats that contain increased protein and energy.

Social benefits might include higher yielding crops that help to improve the food supply in developing countries (Frewer *et al*, 1999). There is a range of potential future technologies that may lead to increased yields in certain parts of the world. For example, genetic engineering which isolates drought, heat, salt and metal tolerance genes, and the development of rice tolerant to submergence, will enable crops to be grown in areas where previously their chance of survival or of providing acceptable yields would have been low.

Consumer benefits may arise from the development of GM foods with enhanced flavour (Frewer *et al*, 1999) and colour (Pretty, 2001). It is also claimed that consumers will benefit from cheaper food because of reduced production costs (where chemical use is reduced and yields are increased) and because of reduced wastage. For example, genetic engineering will enable the application of gene inactivating techniques to 'switch off' the activity of specific genes. This will lead to fruit and vegetables with longer shelf lives. The reduction in wastage, it is claimed, will reduce the cost to the consumer. Doubters might question whether these various cost savings will actually be passed to the consumer. As discussed in chapter four, willingness to accept GM food has been found to occur if GM food is at least 27% cheaper than the conventional equivalent, hence if GM food were to be cheaper because of these new types of modifications, then it might indeed encourage more people to consume it.

It is further claimed that there will be economic benefit because of increased profits for food companies, biotechnology companies and growers which, it is argued, will be good for the economy (Frewer *et al*, 1999).

The potential benefits most relevant to the work presented in this chapter are environmental benefits. As the research reported here involves consumers who have an interest in environmental issues, there may be something of a dilemma for respondents who might generally be anti-GM but who would also support environmental benefits. It is claimed that environmental benefits will arise from a range of new GM technologies. For example, drought resistant crops will reduce the need for irrigation. This will also create a social benefit by allowing crops to grow in areas previously too dry to be productive. Further environmental benefit will arise from the increased use of crops with bt and ht modifications, thus reducing the need for chemical controls. Other developments with environmental benefits will include potatoes and vegetables resistant to fungal pathogens and pests, cereals resistant to storage pests, and nematode resistance in cereals and potatoes. All of these developments should, it is claimed, lead to reduced chemical control and hence create environmental benefits. Also, genetic engineering will enable the development of plants such as strawberries that can grow in frosty conditions. This could have an environmental benefit if locally grown strawberries can be made available for a longer season and reduce the demand for imported strawberries out of season, thus reducing food miles and the associated impacts of transport, while also avoiding the need for heated greenhouses. Table 5.1 summarises the claims that various authors have made about the future benefits of GM technology.

Table 5.1: Claims about future benefits of GM crop technologies

CLAIM ABOUT FUTURE BENEFIT	AUTHOR(S)
Drought resistance	Frewer *et al* 1999 Pretty 2001
Resistance to other environmental stresses e.g. temperature, salt, metal, acid, frost, submergence.	Batie & Ervin 1999 Ando & Khanna 2000 Nuffield Council 1999
Longer shelf life and better shipping characteristics (reduced wastage; reduced energy use e.g. in refrigerated transport).	Frewer *et al* 1999 Pretty 2001 Batie & Ervin 1999 Myhr & Traavik 2002 Franks 1999 Nuffield Council 1999
Enhanced flavour or colour	Pretty 2001 Nuffield Council 1999
Enhanced nutritional content of crop (nutraceuticals) e.g. iron-rich rice; cholesterol reducing grains; plants with improved content of vitamins; modified starch and oil content (e.g. legumes and oats with increased protein and energy); reduced fat crisps and chips.	Pretty 2001 Myhr & Traavik 2002 Nuffield Council 1999
Pharmaceutical crops e.g. potato based vaccine against hepatitis b; anti-cancer vegetables	
Improved nitrogen use in potatoes and wheat.	Pretty 2001
Reduction in the amount of forestland / grassland converted into agricultural production because of improved yields.	Batie & Ervin 1999 Mayer & Stirling 2002
Economic consumer benefits through retail price. Producer benefits through shorter term costs or longer term value added. Benefits to processors through increased profitability.	Mayer & Stirling 2002
Plants with modified oils to meet specific requirements of processors.	Myhr & Traavik 2002 Nuffield Council 1999 Pretty 2001

It is fair to say that for every claim about potential benefit of future GM crops there is a counter-claim about potential risks. These range from fears about the development of new pathogens and toxins (Pretty, 2001; Ando & Khanna, 2000) to concerns about new allergenic risks and the use of anti-biotic marker genes (Royal Society, 2002; Pretty, 2001). Environmental concerns focus on the possibility of resistance to broad-spectrum herbicides developing amongst weeds, or amongst problem pests to built-in pesticides (Pretty, 2001; Batie & Ervin, 1999). There are also concerns about the wider impacts on biodiversity

(Mayer & Stirling, 2002) and problems that may be caused for certified organic producers (Franks, 1999). Importantly, there are recurring concerns expressed about the stability, or lack of it, of inserted genes, hinting at the possibility of unforeseen genetic mutations (Mayer & Stirling, 2002). Risks are summarised in table 5.2.

Table 5.2: Claims about potential risks of GM technologies

CLAIM ABOUT POTENTIAL RISK	AUTHOR(S)
Recombination of viruses and bacteria may produce new pathogens.	Pretty 2001
Insect resistant GM crops function by expressing a toxin and hence there are human health concerns about the presence of that toxin in residues on produce, in groundwater or in the soil.	Ando & Khanna 2000
Insertion of a new gene into an established crop plant or a change in the expression of an existing gene could result in foods being allergenic or toxic or less nutritious.	Pretty 2001 Mayer & Stirling 2002
There may be allergenic risks posed by inhalation of pollen or dust created during milling.	Ando & Khanna 2000
Allergenic sensitisation to a GM plant could occur through skin contact (for example during handling) as well as via the gastrointestinal tract following ingestion of foods.	The Royal Society 2002
Problems may arise from antibiotic resistance marker genes.	Pretty 2001 Ando & Khanna 2000
There may be development of new forms of resistance and secondary pest and weed problems.	Pretty 2001
If key pests develop resistance to Bt, organic growers will lose a major pest control tool.	Batie & Ervin 1999
Changes to farm practices may lead to changes in biodiversity.	Pretty 2001
Transgenic crops could harm the environment through negative impacts on non-target species or biodiversity.	Batie & Ervin 1999 Mayer & Stirling 2002
There may be environmental risks for field boundary ecology. Enhanced weed control efficiency may impact on wildlife. Non-insect species such as birds and small mammals could be affected.	Ando & Khanna 2000
Expressed toxins of insect-resistant plants may harm non-target species when they ingest part of the crop or when beneficial insects prey on the pests targeted by pest resistant GM crops.	Pretty 2001
Accumulated active toxins from Bt corn could damage the soil ecosystem and reduce soil fertility.	Ando & Khanna 2000
Gene flow to other crops and wild relatives may occur.	Batie & Ervin 1999 Mayer & Stirling 2002 Ando & Khanna 2000
Engineered plants may either become weeds themselves or transfer pollen to wild relatives that could become weeds. If these are herbicide resistant they may become extremely difficult to control.	Batie & Ervin 1999 Mayer & Stirling 2002 Ando & Khanna 2000
Genetic inserts may be unstable.	Mayer & Stirling 2002
GM crops may compromise registered organic standards.	Franks 1999

All of the above studies demonstrate the plethora of claims that have been made about the future developments, risks and benefits, of GM technologies and food crops and ingredients. These studies (and others) have been used to construct the questions in the survey relating to potential future risks and benefits (as described in detail in the methodology section below).

The issues discussed above - anti-GM activities, measuring environmental attitude, and claims about future risks and benefits - have all been used to inform the design of the survey used in this part of the thesis. In the next section there is a description of the methodology and discussion of some methodological issues.

5.3 Methodology

5.3.1 The survey

Sixteen organisations in Scotland were contacted in 2003 with a request for help with the distribution of the survey to their members. Groups contacted included local Friends of the Earth (FoE) and Greenpeace groups, as well as anti-GM groups such as Lothian and Borders Biocheck, Highlands and Islands GM, and Munlochy GM Vigil. As discussed above, the decision to include FoE and Greenpeace groups in the study was taken as these organisations have high-profile campaigns against GM technology.

5.3.2 Part one of the survey

In part one of the survey, statements based on the NEP scale were used to investigate the degree to which each respondent held an ecocentric or anthropocentric worldview, and the extent to which there was a range of positions among campaigners. The aim of this part of the survey was to investigate whether attitudes towards the environment could be shown to influence perceptions of risk (and benefit) associated with GM food. Responses to the NEP scale statements were indicated using a four point Likert scale (Likert, 1932), running from strongly agree to strongly disagree. Half of the statements represented an ecocentric position and half represented an anthropocentric position. The former were scored from one to four (strongly disagree to strongly agree) while the latter were scored from four to one (strongly disagree to strongly agree). Thus a high score indicated ecocentrism and a low score indicated anthropocentrism.

Before piloting the survey, a number of the original statements in the NEP scale were re-written where the terminology was considered to be inappropriate. For example, the statement "*The balance of nature is very delicate and easily upset*" was re-written as "*The balance of nature is very fragile and easily disturbed*". The words 'fragile' and 'disturbance' are commonly associated with statements about wildlife habitats, and hence were felt to be more appropriate in this context.

5.3.3 Parts two and three of the survey

In part two of the survey there were six risk-related questions and six benefit-related questions, all concerned with the current situation. This was followed by part three that also featured six risk-related questions and six benefit-related questions, but concerned with the situation in the future. The questions were compiled after a review of the literature (see tables 5.1 and 5.2). Responses to these questions were on a likert scale numbered 1 to 5, from ‘no risk’ (or benefit) to ‘lots of risk’ (or benefit) (or a variation on this phrasing, as appropriate for each question). Scores from these answers enabled an average score to be derived for four categories (to indicate the relative ‘value’ of current risks, future risks, current benefits and future benefits).

The questions within these sections were written so as to address a number of the dimensions of risk within the psychometric paradigm. Specifically there were a number of questions relating to control over exposure. These included:

> *“How much control do you think Scottish residents had over their own exposure to GM crop trials in Scotland?”;* and
>
> *“How much control do you think Scottish consumers have over their own exposure to GM food ingredients?”.*

There were also questions that connected the issue of control over exposure to trust in decision-makers. For example:

> “*To what extent do you think public opinion will be considered before decisions are made about commercial establishment of GM crops in Scotland?”.*

A number of questions were related to the predictability of impacts, for example:

> “*To what extent do you think there will be unpredictable negative impacts on the environment in Scotland from the commercial planting of GM crops?”.*

In addition there were questions relating to the distribution, or equity, of impacts. These included:

> *“How much benefit do you think there is for Scottish consumers from the* current *applications of GM technology to food production?”;*
>
> *“How much benefit do you think people in developing countries gain from the application of* current *GM technology to food production?”;*
>
> *“How much economic benefit do you think there is for farmers in other countries who grow commercial GM crops with built-in pesticide?”;*
>
> *“How much economic benefit do you think there is for biotechnology companies such as Bayer and Monsanto from commercial GM crops grown in other countries?”;*

"To what extent do you think the crops of organic farmers were at risk of contamination from GM plants grown in the UK as part of GM crop trials?".

5.3.4 Part four of the survey

Socio-demographic questions and a number of questions relating to the geographical context of the respondent were included in the final section of the survey. The aim was to use this information to investigate the extent to which socio-demographic and contextual details affected environmental values, and valuation of risks and benefits.

5.3.5 Pilot

Before distribution, the survey was piloted with peers and colleagues. After piloting, a number of the original NEP scale statements were found to be problematic for respondents. Specifically, the statements that Dunlap *et al* (2000) identified as being related to the dimension 'limits to growth' were felt to represent out-dated concepts and were removed. Hence the statement "*We are approaching the limit of the number of people the earth can support*" was not included. (See appendix three for the full survey).

5.3.6 Analysis

After initial descriptive statistics a combination of T tests and ANOVA were conducted on the results in order to test for statistical differences between means. The analysis was carried out on the socio-demographic variables and the NEP scores, and the socio-demographic variables and the mean values assigned to the four risk and benefit categories (current risks, current benefits, future risks, future benefits). ANOVA was also conducted between NEP scale results and the four risk and benefit categories. Following this attempts were made to investigate possible interactions between variables, using two way ANOVA.

The survey therefore addressed a number of questions. First: "How might campaigners rate the (perceived) current and future risks and benefits of GM technology in food?". Second: "Could members of anti-GM campaign groups and environmental NGOs be segmented into groups with different attitudes towards the human-environment relationship, and if so, was this correlated with perception of risk associated with GM technology?". Third: "Do attitudes towards GM technology vary between different socio-demographic segments of the target group, as claimed by previous studies with the general population?.

Overall, the survey was designed to address a number of the factors discussed in chapter three as being relevant to an understanding of risk perceptions. These were environmental values, the relationship between perceived risks and perceived benefits, a number of the psychometric paradigm items, trust in regulators, and socio-demographic and cultural factors. In the section that follows, results are presented and discussed.

5.4 Results

5.4.1 Respondents

Five organisations agreed to help with distribution of the survey to their members, 31% of those contacted. The total number of usable responses was 38. As details of membership numbers of the individual groups is not known it is not possible to say what is the response rate.

The typical respondent was female, aged between 30-49 years old, with a postgraduate degree, and living in a household with children (table 5.3). Typically, respondents did not know whether or not they were living near the site of a GM FSE trial, and the majority classified themselves as urban residents (68%). Average annual income of household was £20,000-30,000.

Table 5.3 Respondent details

RESPONDENT DETAILS		N	PERCENT
GENDER			
	Female	18	47.4
	Male	16	42.1
	No response	4	10.5
EDUCATION			
	O grades	2	5.3
	Highers	6	15.8
	Undergraduate degree	10	26.3
	Postgraduate degree	15	39.5
	Other	4	13.2
HOUSEHOLD			
	No children	11	28.9
	With children	21	55.3
	Unknown	6	15.8
PLACE OF RESIDENCE			
	Urban	26	68.4
	Rural	8	21.1
	No response	4	10.5
GM_TRIAL			
	Near trial	11	28.9
	Not near trial	13	34.2
	Don't know	14	36.8
AGE_GROUP			
	20-29 years	2	5.3
	30-39 years	10	26.3
	40-49 years	10	26.3
	50-59 years	7	18.4
	60-69 years	3	7.9
	No answer	6	15.8
HOUSEHOLD INCOME			
	Under £10,000	4	10.5
	£10,001-£20,000	5	13.2
	£20,001-£30,000	10	26.3
	£30,001-£40,000	6	15.8
	£40,001-£50,000	3	7.9
	Over £50,000	5	13.2
	No response	5	13.2
MEMBERSHIP OF GROUP			
	Anti-GM group	5	13.2
	Environment group	13	34.2
	Not specified which	20	52.6

5.4.2 New Ecological Paradigm scale

The internal consistency of the NEP scale was tested. The Cronbach's Alpha value based on standardised items was found to be 0.629. While the generally preferred level is to have a value greater than 0.7 (Nunnally, 1978), only values below 0.5 are considered unacceptable (Gliem & Gliem, 2003; George & Mallery, 2003). This is particularly so if the scale contains few items, that is, limited to 10-15, as in this case, when anything over 0.5 represents an acceptable level of internal consistency (Kehoe, 1995; Leigh, no date). If the scale is exploratory, values of 0.60 are considered acceptable (Hair *et al.*, 1998). The study type also influences acceptable values. For example, in psychology, the standard of reliability required varies between fields, such that cognitive tests (tests of intelligence or achievement) are expected to be more reliable and thus demonstrate higher values for co-efficient alpha, than tests of attitudes or personality, where lower values are acceptable (Nagel, 2006; Kline, 1999). The scale used here is designed to measure the values contributing to environmental attitudes. Numerous studies report acceptable values below 0.7 (see for example, Ogilvie *et al*, 2007; Cunningham *et al*, 2001; Wilson *et al*, 2008; Mears *et al*, 2004).

As noted above, many previous studies using the NEP scale have found the scale to measure different numbers of facets of a different nature to those claimed by the original authors to be represented by the scale. In order to investigate whether similar facets could be said to be incorporated in this amended and shortened version of the NEP scale, as in the 15 item scale from which it was derived, factor analysis (Principal Components Analysis plus varimax rotation) was performed on the results. Using the eigenvalue criterion (George & Mallery, 2003) as a cut-off point for selection of factors (eigenvalues greater than one) revealed four factors, explaining 68% of the variance. These four factors can be labelled 'The laws and balance of nature'; 'Environmental change'; 'Human superiority'; and 'Human impact on the planet'. Forced selection of one, two and three factors revealed less satisfactory results that explained less variance, included unacceptably low factor loadings, were more difficult to interpret, and in the case of the two factor solution, included a bi-polar factor that effectively meant there was a third factor on which only one item loaded. To conclude, therefore, as with previous studies, the components addressed by this study are not exactly the same as those identified by Dunlap *et al*, but are valid facets of environmental beliefs.

As internal consistency was acceptable it was possible to treat the 10 item NEP scale as measuring an overall worldview. Hence, the results from the NEP scale were treated as a single variable. The results were scored as follows: Lowest possible score (10) represented very strong anthropocentric; highest possible score (40) represented very strong ecocentric. The average score from results was 34, strong ecocentric (table 5.4). The majority of respondents could be classified as being ecocentric, based on the results of the NEP scale. Only 8% were neutral – i.e. neither anthropocentric nor ecocentric, and none were anthropocentric.

Table 5.4 NEP results

NEP CATEGORY	N	PERCENTAGE
Neutral	3	7.9
Weak ecocentric	8	21.1
Strong ecocentric	23	60.5
Very strong ecocentric	4	10.5

Results of responses to individual NEP statements revealed that 89.5% of respondents strongly agreed with the statement "*human behaviour is damaging the environment*", while 50% strongly disagreed with the statement "*humans are meant to have stewardship over the rest of the environment*" (all statements and responses are appended). The average scores for these statements were 3.82 and 3.11 respectively[7]. All ten statements and the average scores are presented in table 5.5.

Table 5.5 Average scores for each NEP statement

STATEMENT	AVERAGE SCORE	STD. DEVIATION	LEVEL OF AGREEMENT / DISAGREEMENT
Humans have the right to modify the environment to suit their needs	2.61	.887	3=partially disagree
Human ingenuity will ensure that we do not make the earth uninhabitable	3.26	.790	3=partially disagree
The environment is able to adapt to cope with the impacts of industrial societies	3.11	.950	3=partially disagree
The so-called ecological crisis facing the planet has been exaggerated	3.74	.609	4=strongly disagree
Humans were meant to have stewardship over the rest of the environment	3.11	.798	3=partially disagree
When humans interfere with 'nature' it often produces negative consequences	3.39	.718	3=partially agree
Human behaviour is damaging the environment	3.82	.446	4=strongly agree
Plants and animals have as much right to exist as human beings	3.61	.563	4=strongly agree
Despite our greater intelligence humans are still subject to the 'laws of nature'	3.82	1.203	4=strongly agree
The balance of nature is fragile and easily disturbed	3.34	.781	3=partially agree

In order to investigate the impact of the socio-demographic variables on the NEP score, T tests and ANOVA were conducted. The female respondents were found to be more strongly ecocentric than men, with an average NEP score of 36 as opposed to 32 (table 5.6). None of the other socio-demographic variables in this study had any significant effect on the NEP score.

[7] Note that 'ecocentric' statements scored 1 to 4 'strongly disagree' to 'strongly agree' while 'anthropocentric' statements scored 1 to 4 'strongly agree' to 'strongly disagree'.

Table 5.6: Respondent variables and NEP score

VARIABLE	MEAN VALUES				T-TEST STATISTIC	DEGREES OF FREEDOM	F STATISTIC	P-VALUE
Gender					3.51	32	-	0.001[a]
	Female	Male						
	35.94	32.38						
Place of residence					-1.81	32	-	0.079
	Urban	Rural						
	33.69	36.13						
Group membership					0.47	16	-	0.646
	Anti-GM	Environment						
	34.80	33.85						
Household					-1.17	30	-	0.251
	Without children	With children						
	33.18	34.67						
Education					-	-	1.90	0.134
	O grade	Higher	U/deg	P/deg				
	35.00	33.83	35.60	33.53				
Near trial?					-	-	0.32	0.725
	Near trial	Not near	DK					
	34.27	33.15	34.07					

[a] Significant at the 0.01 level

5.4.3 Risk and benefit questions

Results from the risk and benefit question categories revealed that, of the four categories, the highest average score was for future risks (3.86), followed by current risks (3.79) and then current benefits (2.30). Lowest of all were future benefits (1.67). Next, consideration is given to responses to individual questions included in parts two and three of the survey.

In response to the question "*to what extent do you think people in developing countries will benefit from the production of GM crops with added vitamins?"* 50% of respondents said 'not at all' or 'very little'. Only 5% said 'some'. When asked "*to what extent do you think growing commercial GM crops with built-in pesticide (in other countries) reduces the need for agri-chemicals*?" only 8% of respondents answered 'some reduction'. The majority (45%) answered 'no reduction at all' or 'very little reduction'. Similarly, in response to the question "*to what extent do you think growing commercial herbicide-resistant GM crops in other countries (which leads to better targeting of herbicides) reduces agri-chemical use?*", 45% of respondents answered 'no reduction at all' or 'very little reduction'. As regards the environmental benefits that GM technologies might offer *in the future*, a similar story is revealed. Fifty percent of respondents did not expect yield-increasing GM species to help to preserve or re-instate 'natural' habitats. When asked "*to what extent do you think there will be health risks for consumers from eating GM food* *products and ingredients*?" 24% said 'very little risk', 30% said 'some' or 'a lot'. Similarly, when asked about the health risks for people living in the vicinity of field scale trials, 37% said they thought there had been 'no risk at all' or 'very little risk' while 18% thought there was 'a lot' or 'some risk'.

As noted above, a number of the questions were formulated to address some of the psychometric paradigm dimensions of risk. Responses to some of these are now presented. When considering the issue of control over exposure to GM food, 45% believed they had 'no' or 'very little control' while only 8% believed they had 'some' or 'a lot of control' over exposure. Following on from this, there was a question connecting the issue of control over exposure, to trust in decision-makers and those in authority. The question was asked: "*To what extent do you think public opinion will be considered before decisions are made about commercial establishment of GM crops in Scotland*?". Forty two percent of respondents indicated that they believed there would be 'none' or 'very little' consideration of public opinion, while only 8% thought there would be 'some' or 'a lot'.

There was a question relating to the predictability of impacts that asked respondents what they believed would be the extent of unpredictable negative environmental impacts if GM crops were grown commercially. Sixty eight percent of respondents replied that they believed there would be 'some' or 'a lot' of unpredictable negative impacts. The rest were unsure.

In addition there were a number of questions relating to the distribution or equity of impacts; that is, which groups of people would benefit and which groups would face risks. Groups considered included Scottish consumers, people in developing countries, farmers in other countries, biotechnology companies, farmers in developing countries, organic farmers, conventional farmers, and residents living near to the FSE trial sites. Respondents generally believed there was 'little' or 'no' benefit for Scottish consumers or people in developing countries but 'a lot' of economic benefit for biotechnology companies. When it came to considering some potential GM developments such as foods with added vitamins, longer shelf-life or improved flavour, very few, if any, respondents expected any benefits for consumers. Ten percent of respondents believed there was 'some' economic benefit for farmers in other countries growing bt crops, but 47% thought there was 'little' or 'no' benefit for them. Thirteen percent of respondents believed that farmers in developing countries would benefit from drought-resistant GM crops. When considering the impact on organic farmers, the vast majority of respondents believed they faced ‘a lot’ or ‘some’ risk of contamination from GM crop trials (see appendix four for percentage responses to all risk and benefit questions).

The next stage of the research was to investigate whether there were any relationships between the socio-demographic variables, the geographical contextual factors, the level of ecocentricity, and the responses to the risk and benefit questions. Investigation was carried out by conducting T tests and ANOVA to test for statistically significant differences between means. Results are presented below.

5.4.4 Socio-demographic factors

The study revealed that women considered the risks of current GM technology to be greater than men considered them to be (average value of current risks was 4 as opposed to 3.5) (table 5.7). In addition, the average value of future risks was 4.1 for women as opposed to 3.6 for men.

Level of education was also shown to have an effect on how great respondents believe the risks of current GM technologies to be (table 5.7). Specifically, respondents with a postgraduate degree valued current risks of GM technology lower than those respondents whose highest educational qualification was O grade, or undergraduate degree.

5.4.5 Geographical, cultural factors

The study revealed that people living in urban areas considered the benefits of current GM technology to be greater than those people living in rural areas (benefits valued at an average 2.4 as opposed to 1.9) (table 5.7). There was also evidence that individuals living near to a FSE trial site placed a lower average value on the benefits of current GM technology than those not living near an FSE trial site or those who did not know whether there was an FSE trial nearby. When considering future risks, the average value was 4.5 for people living in rural areas, as opposed to 3.7 for people living in urban areas. The average value was 4.7 for people who were members of anti-GM campaign groups as opposed to 3.8 for people who were members of environment groups (table 5.8). People living in urban areas were shown to value the future benefits of GM technology higher than those in rural areas (average value 1.8 as opposed to 1.2) (table 5.8). Those who did not live near to a site where there were FSEs considered the potential future benefits of GM technology to be greater than those who lived near to FSE trial sites.

5.4.6 Environmental values

In addition to the socio-demographic and geographical factors it was possible, using the NEP scale results, to investigate the extent to which environmental values influenced risk and benefit perceptions. Results revealed that the more strongly ecocentric was a respondent, the greater the value they placed on risks of current GM technologies. The NEP scale results for the other three categories (current benefits, future risks, future benefits) were not found to be significant.

Table 5.7: Respondent variables and current risks and benefits

VARIABLE	MEAN				T-TEST STATISTIC	DEGREES OF FREEDOM	F STATISTIC	P-VALUE
CURRENT RISKS								
Gender					2.11	25	-	0.045[a]
	Female	Male						
	4.04	3.52						
Place of residence					-1.88	25	-	0.072
	Urban	Rural						
	3.66	4.22						
Group membership					0.75	10	-	0.473
	Anti-GM	Environment						
	4.06	3.70						
Household					-0.40	23	-	0.695
	Without children	With children						
	3.70	3.82						
Education					-	-	3.88	0.023[a]
	O grade	Higher	U/deg	P/deg				
	4.42	3.84	4.06	3.26				
Near trial?					-	-	1.67	0.209
	Nr trial	Not nr trial	Don’t know					
	3.70	3.57	4.08					
NEP group					-	-	5.88	0.008[b]
	Weak eco	Strong eco	V strong eco					
	3.21	3.59	4.22					
CURRENT BENEFITS								
Gender					0.29	25	-	0.776
	Female	Male						
	2.33	2.26						
Place of residence					2.07	25	-	0.049[a]
	Urban	Rural						
	2.41	1.92						
Group membership					-1.16	10	-	0.271
	Anti-GM	Environment						
	1.89	2.27						
Household					-1.16	10	-	0.271
	Without children	With children						
	2.24	2.30						
Education					-	-	0.63	0.606
	O grade	Higher	U/deg	P/deg				
	2.32	2.27	2.16	2.51				
Near trial?					-	-	3.90	0.034[a]
	Near trial	Not near	DK					
	1.80	2.45	2.42					
NEP group					-	-	0.60	0.559
	Weak eco	Strong eco	V strong eco					
	2.52	2.33	2.18					

[a]Significant at the 0.05 level; [b]Significant at the 0.01 level

Table 5.8: Respondent variables and future risks and benefits

VARIABLE	MEAN				T-TEST STATISTIC	DEGREES OF FREEDOM	F STATISTIC	P-VALUE
FUTURE RISKS								
Gender					2.18	25	-	0.039[a]
	Female	Male						
	4.12	3.58						
Place of residence					-2.88	25	-	0.008[b]
	Urban	Rural						
	3.68	4.50						
Group membership					2.22	10	-	0.05[a]
	Anti-GM	Environment						
	4.66	3.83						
Household					-0.68	23	-	0.502
	Without children	With children						
	3.75	3.94						
Education					-	-	2.11	0.128
	O grade	Higher	U/deg	P/deg				
	4.08	3.97	4.13	3.40				
Near trial?					-	-	1.08	0.355
	Near trial	Not near	DK					
	4.08	3.63	3.99					
NEP group					-	-	2.96	0.071
	Weak eco	Strong eco	V strong eco					
	3.48	3.66	4.22					
FUTURE BENEFITS								
Gender					0.13	25	-	0.894
	Female	Male						
	1.69	1.65						
Place of residence					2.32	25	-	0.029[a]
	Urban	Rural						
	1.80	1.23						
Group membership					-1.32	10	-	0.216
	Anti-GM	Environment						
	1.17	1.66						
Household					-0.14	23	-	0.887
	Without children	With children						
	1.65	1.68						
Education					-	-	0.40	0.751
	O grade	Higher	U/deg	P/deg				
	2.00	1.57	1.59	1.78				
Near trial?					-	-	3.70	0.040[a]
	Near trial	Not near	DK					
	1.23	1.95	1.63					
NEP group					-	-	0.67	0.520
	Weak eco	Strong eco	V strong eco					
	1.81	1.77	1.52					

[a]Significant at the 0.05 level
[b]Significant at the 0.01 level

5.4.7 Testing for interaction

One way ANOVA and T tests gave some indication of what was explaining mean values for the NEP score, and the current risks, current benefits, future risks and future benefits scores. However, these analyses do not look for interaction between variables. Therefore, two way ANOVA was subsequently conducted in order to investigate this.

During the one way ANOVA and T tests procedures each independent variable was examined individually to assess its potential importance separately. In the two way ANOVA procedure those variables that were found to be significant in the one way ANOVA and T tests were retained and re-examined to explore any relationships between the variables. Due to the fact that the T tests and one way ANOVA procedures run for the NEP score revealed only one significant variable (gender), no further analysis was conducted on that part of the dataset. Additionally, as the primary interest was to identify factors influencing risk perceptions, no further analysis was conducted on the current benefits or future benefits part of the dataset.

Current risks

Having run T tests and ANOVA for the variables in the campaigner dataset, results suggested that three variables may be important in explaining the 'current risk' values. These were the 'gender' variable, 'education' variable and the 'NEP group' variable (p values 0.045, 0.023 and 0.008 respectively). Next, two way ANOVA was run with pairs of these three variables in turn to investigate the questions "is there a gender by education interaction?", "is there a gender by NEP group interaction?" or "is there an education by NEP group interaction?". For example, does 'gender' have one effect on one level of 'education' but a different effect on another level of 'education'? Perhaps females with an undergraduate degree have higher current risk values than males but males with a postgraduate degree have higher current risk values than females. The two way ANOVA aims to test this.

Gender by education interaction

Table 5.9 below displays descriptive statistics for each combination of factors in the model. There seems to be an education effect. For example, on average, those with 'O' grades or equivalent have a current risk value of 4.42, while those with a postgraduate degree have a current risk value of 3.26. There also appears to be a gender effect. On average, females have a current risk value of 4.02 compared to 3.52 for males. Lastly, there may be an interaction effect between gender and education, because the mean differences in current risk values by gender vary between education levels. For example, males with highers have a lower current risk value than males with an undergraduate degree, but this trend is reversed for females.

Table 5.9 Descriptive Statistics: gender by education

GENDER	EDUCATION	MEAN	STD. DEVIATION	N
Female	O grades etc	4.4200	.35355	2
	Highers	4.5000	.00000	2
	Undergraduate degree	4.0320	.81128	5
	Postgraduate degree	3.5625	.53375	4
	Total	4.0192	.66025	13
Male	Highers	3.4000	.24269	3
	Undergraduate degree	4.0880	.48194	5
	Postgraduate degree	3.0260	.45153	5
	Total	3.5208	.62842	13
Total	O grades etc	4.4200	.35355	2
	Highers	3.8400	.62646	5
	Undergraduate degree	4.0600	.62978	10
	Postgraduate degree	3.2644	.53733	9
	Total	3.7700	.68073	26

Running two way ANOVA with these two factors showed that the significance value for each term, except the gender by education interaction, is less than 0.05. Therefore, each term, except the interaction, is confirmed as being statistically significant, as found in the one way ANOVA and T tests run previously. So there is a significant main effect for gender (p value 0.035) and a significant main effect for education (p value 0.028) but no significant gender by education interaction (p value 0.164).

However, Levene's test of equality of error variances is significant, showing that the error variance of the dependent variable is not equal across groups. Since this is an assumption of ANOVA, there is a need to be careful in interpreting the ANOVA results.

Given the Levene's test statistic it may be useful to study the spread versus level plot. The spread-versus-level plot is a scatterplot of the cell means and standard deviations from the descriptive statistics table. It provides a visual test of the equal variances assumption and helps to assess whether violations of the assumption are due to a relationship between the cell means and standard deviations. There is no apparent pattern in this plot, so there is no indication of such a relationship here (figure 5.1). In this case the ANOVA results can be taken as being reliable, meaning that there is indeed a gender main effect and an education main effect.

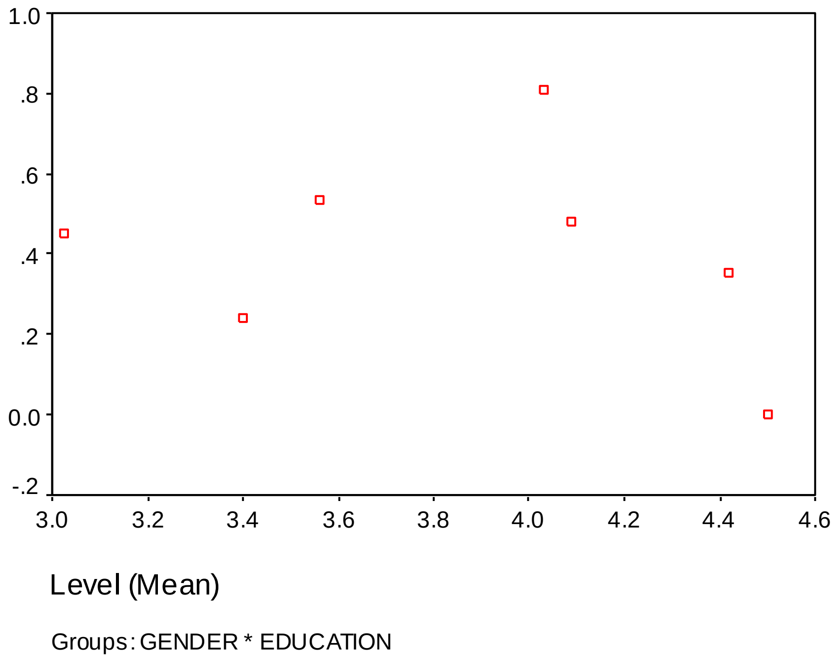

Figure 5.1 Spread versus level plot: Gender by education

A statistically significant effect in ANOVA can be further investigated using follow-up tests. This is done to investigate which groups are different from which other groups. Follow up tests are distinguished in terms of whether they are planned (a priori) or post hoc. Post hoc tests apply in this case.

As noted, the main ANOVA result suggests that there is a main effect for both education and gender. Since the variances may be significantly different this influences the choice of post-hoc test. The Games-Howell post-hoc test does not rely on homogeneity of variance (MicrobiologyBytes, 2009) and so can be used to investigate which differences are significant in this case. The Games-Howell post-hoc test demonstrates that there is a significant difference in the current risk values of those respondents with postgraduate degrees and those with undergraduate degrees (p value 0.039) (table 5.10). Note that post hoc tests could not be performed for gender because there are fewer than three groups in the variable.

Table 5.10 Games-Howell post-hoc test: Education

(I) EDUCATION	(J) EDUCATION	MEAN DIFFERENCE (I-J)	STD. ERROR	SIG.	95% CONFIDENCE INTERVAL	
					Lower Bound	Upper Bound
O grades etc	Highers	.5800	.37549	.499	-1.0240	2.1840
	Undergraduate degree	.3600	.31963	.706	-1.3827	2.1027
	Postgraduate degree	1.1556	.30754	.137	-.7552	3.0663
Highers	O grades etc	-.5800	.37549	.499	-2.1840	1.0240
	Undergraduate degree	-.2200	.34373	.916	-1.3164	.8764
	Postgraduate degree	.5756	.33252	.374	-.5122	1.6633
Undergraduate degree	O grades etc	-.3600	.31963	.706	-2.1027	1.3827
	Highers	.2200	.34373	.916	-.8764	1.3164
	Postgraduate degree	.7956(*)	.26785	.039	.0340	1.5571
Postgraduate degree	O grades etc	-1.1556	.30754	.137	-3.0663	.7552
	Highers	-.5756	.33252	.374	-1.6633	.5122
	Undergraduate degree	-.7956(*)	.26785	.039	-1.5571	-.0340

Based on observed means.
* The mean difference is significant at the .05 level.

Gender by NEP group interaction

Next, the same two way ANOVA test was run for gender and NEP group to see if there was any interaction between these two variables in how they impacted on the current risk values.

Table 5.11 below displays descriptive statistics for each combination of factors in the model. There seems to be an NEP group effect. For example, on average, those who are weak ecocentrics have a current risk value of 3.21, while those who are very strong ecocentrics have a current risk value of 4.22. There also appears to be a gender effect. On average, females have a current risk value of 4.04 compared to 3.52 for males. However, it looks unlikely that there is an interaction effect between gender and NEP group because in the case of both males and females the current risk values are generally higher the more ecocentric the respondent (although note that this is not quite the case for males).

Table 5.11 Descriptive Statistics: Gender by NEP group

Gender	Nep_Grp	Mean	Std. Deviation	N
Female	Weak ecocentric	3.0000	.	1
	Strong ecocentric	4.0520	.62363	5
	Very strong ecocentric	4.1550	.60202	8
	Total	4.0357	.63733	14
Male	Weak ecocentric	3.2767	.38682	3
	Strong ecocentric	3.2529	.45628	7
	Very strong ecocentric	4.3900	.34828	3
	Total	3.5208	.62842	13
Total	Weak ecocentric	3.2075	.34481	4
	Strong ecocentric	3.5858	.65140	12
	Very strong ecocentric	4.2191	.53852	11
	Total	3.7878	.67388	27

Nevertheless the marginal means profile plot seems to suggest that there may indeed be an interaction effect for gender and NEP group since the lines are not at all parallel and in fact intersect twice (figure 5.2).

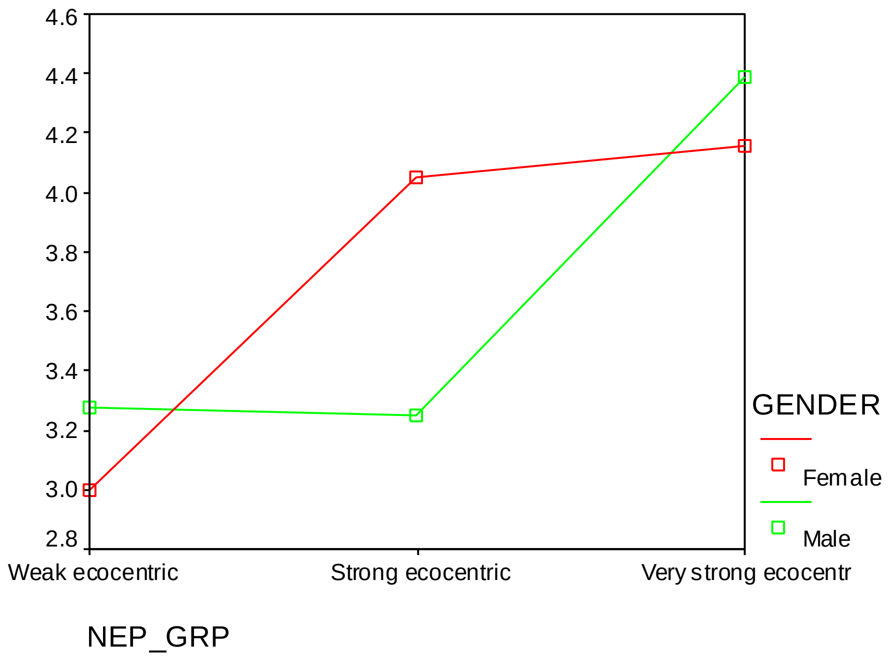

Figure 5.2 Estimated marginal means profile plot for current risks: Gender by NEP group

The analysis of variance table is shown (table 5.12). Only the significance value for NEP group is less than 0.05. Therefore only this term is found to be statistically significant at this level. So there is a significant main effect for NEP group (p value 0.007) but not for gender (p value 0.714). There is no significant NEP group by gender interaction at the 95% significance level but there is at the 90% significance level (p value 0.080).

The partial eta squared statistic reports the ‘practical’ significance of each term, based upon the ratio of the variation (sum of squares) accounted for by the term, to the sum of the variation accounted for by the term and the variation left to error. Larger values of partial eta squared indicate a greater amount of variation accounted for by the model term, to a maximum of 1. The partial eta squared value for the interaction (0.213) confirms the relative importance in influencing current risk values. Levene’s test of equality of error variances is non-significant (p value 0.440), confirming that the error variance of the dependent variable is equal across groups and that the ANOVA results can therefore be treated as valid.

Table 5.12 Tests of between-subjects effects: Gender by NEP group

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	5.923(a)	5	1.185	4.228	.008	.502
Intercept	229.364	1	229.364	818.644	.000	.975
GENDER	.039	1	.039	.138	.714	.007
NEPGROUP	3.508	2	1.754	6.261	.007	.374
GENDER * NEPGROUP	1.597	2	.799	2.850	.080	.213
Error	5.884	21	.280			
Total	399.183	27				
Corrected Total	11.807	26				

a R Squared = .502 (Adjusted R Squared = .383)

NEP group by education interaction

Next, two way ANOVA was conducted for NEP group and education to investigate if there was any interaction between these factors in influencing the current risk values. Descriptive statistics suggested there may be an NEP group effect since mean values differed between groups (table 5.13). Likewise it appeared that there might be an education effect. It appeared unlikely that there was an interaction effect since mean values generally decreased (in both NEP groups where there was more than one education level), as those education levels increased.

Table 5.13 Descriptive Statistics: NEP group by education

NEP_GRP	EDUCATION	MEAN	STD. DEVIATION	N
Weak ecocentric	Postgraduate degree	3.2075	.34481	4
	Total	3.2075	.34481	4
Strong ecocentric	O grades etc	4.4200	.35355	2
	Highers	3.4000	.24269	3
	Undergraduate degree	3.4233	.36828	3
	Postgraduate degree	3.1567	.89030	3
	Total	3.5255	.64701	11
Very strong ecocentric	Highers	4.5000	.00000	2
	Undergraduate degree	4.3329	.51009	7
	Postgraduate degree	3.5400	.41012	2
	Total	4.2191	.53852	11
Total	O grades etc	4.4200	.35355	2
	Highers	3.8400	.62646	5
	Undergraduate degree	4.0600	.62978	10
	Postgraduate degree	3.2644	.53733	9
	Total	3.7700	.68073	26

The profile plot of the estimated marginal means also suggested that there was unlikely to be an interaction between education and NEP group since the lines show similar distances between points for both strong ecocentric and very strong ecocentric. However the plot is incomplete due to missing values in some cells (figure 5.3).

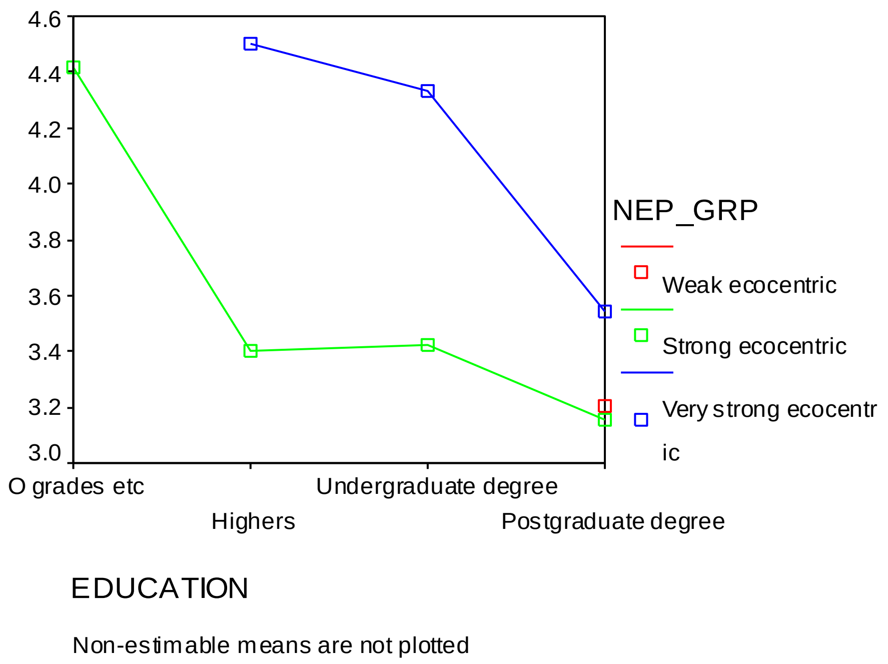

Figure 5.3 Estimated marginal means of current risks: NEP group by education

The results from the two way ANOVA confirmed the main effect for NEP group (p value 0.012) and for education (p value 0.017) but demonstrated that there was indeed no interaction effect between these two factors (0.495). The importance of both NEP group and education in influencing current risk values is further demonstrated by the partial eta squared values (0.390 and 0.422 respectively) (table 5.14).

Table 5.14 Tests of between-subjects effects: NEP group by education

SOURCE	TYPE III SUM OF SQUARES	DF	MEAN SQUARE	F	SIG.	PARTIAL ETA SQUARED
Corrected Model	7.400(a)	7	1.057	4.546	.004	.639
Intercept	285.546	1	285.546	1228.050	.000	.986
NEPGROUP	2.677	2	1.339	5.757	.012	.390
QUALIFIC	3.060	3	1.020	4.386	.017	.422
NEPGROUP * QUALIFIC	.340	2	.170	.731	.495	.075
Error	4.185	18	.233			
Total	381.120	26				
Corrected Total	11.585	25				

a R Squared = .639 (Adjusted R Squared = .498)

The ANOVA results are valid as Levene's test of equality of error variances is non significant (0.091) thus confirming homogeneity of variance.

While the ANOVA results confirmed the importance of both NEP and education as main effects influencing current risk values, the results do not indicate which levels of the factors are important. Bonferroni post hoc tests were conducted to investigate which groups (levels) were significantly different from each other. The test showed that those respondents with postgraduate degrees have significantly different current risk values to those with either undergraduate degrees (p value 0.013) or O grades (p value 0.040) (table 5.15). For the NEP group, the test showed that those respondents classed as very strong ecocentrics have significantly different current risk values to those who are either weak ecocentrics (p value 0.006) or strong ecocentrics (p value 0.010) (table 5.16).

Table 5.15 Bonferroni post-hoc test: Education

(I) Education	(J) Education	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
O grades etc	Highers	.5800	.40344	1.000	-.6153	1.7753
	Undergraduate degree	.3600	.37351	1.000	-.7466	1.4666
	Postgraduate degree	1.1556(*)	.37696	.040	.0387	2.2724
Highers	O grades etc	-.5800	.40344	1.000	-1.7753	.6153
	Undergraduate degree	-.2200	.26411	1.000	-1.0025	.5625
	Postgraduate degree	.5756	.26896	.278	-.2213	1.3724
Undergraduate degree	O grades etc	-.3600	.37351	1.000	-1.4666	.7466
	Highers	.2200	.26411	1.000	-.5625	1.0025
	Postgraduate degree	.7956(*)	.22156	.013	.1391	1.4520
Postgraduate degree	O grades etc	-1.1556(*)	.37696	.040	-2.2724	-.0387
	Highers	-.5756	.26896	.278	-1.3724	.2213
	Undergraduate degree	-.7956(*)	.22156	.013	-1.4520	-.1391

Based on observed means.
* The mean difference is significant at the .05 level.

Table 5.16 Bonferroni post-hoc test: NEP group

(I) NEP_GRP	(J) NEP_GRP	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Weak ecocentric	Strong ecocentric	-.3180	.28155	.821	-1.0610	.4251
	Very strong ecocentric	-1.0116(*)	.28155	.006	-1.7546	-.2686
Strong ecocentric	Weak ecocentric	.3180	.28155	.821	-.4251	1.0610
	Very strong ecocentric	-.6936(*)	.20561	.010	-1.2363	-.1510
Very strong ecocentric	Weak ecocentric	1.0116(*)	.28155	.006	.2686	1.7546
	Strong ecocentric	.6936(*)	.20561	.010	.1510	1.2363

Based on observed means.
* The mean difference is significant at the .05 level.

Future risks

Having run T tests and ANOVA for the variables in the campaigner dataset, results suggested that three variables may be important in explaining the ‘future risk’ values. These were the ‘gender’ variable, ‘place’ variable and the ‘group’ variable (p values 0.039, 0.008 and 0.05 respectively). In this case the place variable relates to whether the respondent lived in an urban or a rural area, and the group variable relates to whether the respondent is a member of an anti-GM campaign group or an environmental campaign group. The intention was to run two way ANOVA with pairs of these three variables in turn to investigate the questions “is there a gender by place interaction?”, “is there a gender by group interaction?” or “is there a place by group interaction?”. However, missing values proved to be a problem here. There were no values for males in the anti-GM campaign group category and no members of environmental campaign groups in rural areas, so it was only possible to run the analysis to examine the question “is there a gender by place interaction?”. For example, perhaps ‘females’ living in rural areas have higher future risk values than females in urban areas but males in rural areas have lower future risk values than males in urban areas. The two way ANOVA aims to test this.

Gender by place of residence interaction

Descriptive statistics suggested that indeed there might be both a gender main effect (as mean future risk values were higher for females than mean future risk values for males), and a place of residence main effect (because mean future risk values were higher in rural areas than urban) (table 5.17). It appeared unlikely that there was an interaction effect as for both males and females, values increased from urban to rural, hence the relationship was in the same direction in both cases. The estimated marginal means profile plot appears to confirm the lack of an interaction effect as it demonstrates parallel lines (figure 5.4).

Table 5.17 Descriptive Statistics: Gender by place

GENDER	PLACE	MEAN	STD. DEVIATION	N
Female	Urban	3.8930	.71630	10
	Rural	4.7050	.25000	4
	Total	4.1250	.71732	14
Male	Urban	3.4873	.53867	11
	Rural	4.0850	.58690	2
	Total	3.5792	.56647	13
Total	Urban	3.6805	.64737	21
	Rural	4.4983	.45705	6
	Total	3.8622	.69470	27

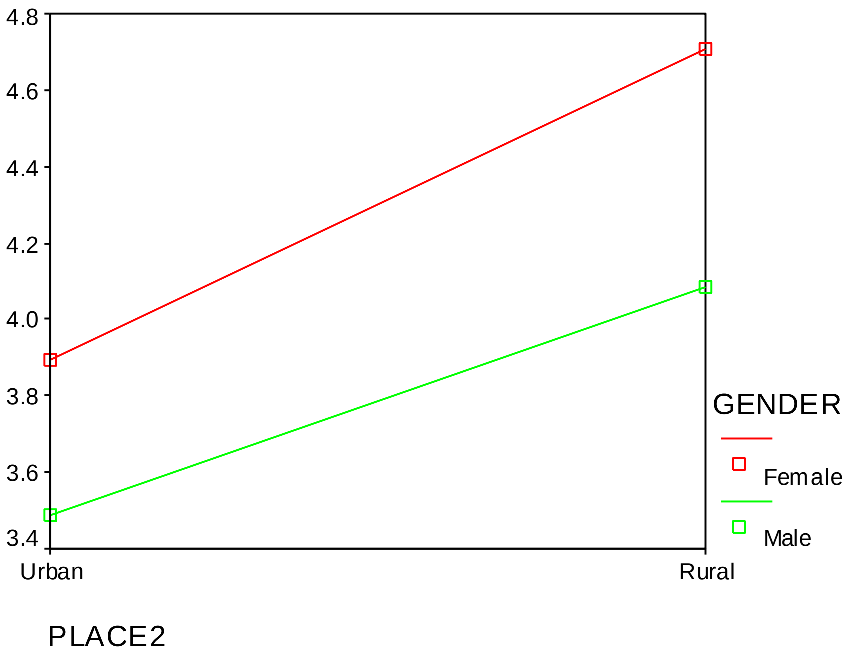

Figure 5.4 Estimated marginal means for future risks: Gender by place

The ANOVA procedure confirmed a main effect for place (p value 0.022) and a main effect for gender at the 90% significance level (p value 0.087) (table 5.18). No interaction effect was found between the two variables. This lack of interaction is confirmed by the partial eta squared statistic of 0.006. Levene's test of equality of error variances was non-significant (p value 0.164) confirming the homogeneity of variance and therefore the validity of the ANOVA results.

Table 5.18 Tests of between-subjects effects: Gender by place

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	4.496(a)	3	1.499	4.281	.015	.358
Intercept	277.899	1	277.899	793.861	.000	.972
GENDER	1.118	1	1.118	3.194	.087	.122
PLACE2	2.112	1	2.112	6.034	.022	.208
GENDER * PLACE2	.049	1	.049	.139	.712	.006
Error	8.051	23	.350			
Total	415.300	27				
Corrected Total	12.548	26				

a R Squared = .358 (Adjusted R Squared = .275)

Post hoc tests could not be computed for these variables because there are fewer than three groups (levels).

5.5 Discussion

5.5.1 Respondents

Although the aim was not to target a general population sample, it is nevertheless instructive to compare the demographics of the sample with results from the Scottish Household Survey (SHS) (Dudleston *et al*, 2002). Fifty-five percent of households in the survey population were households with children. This compares to the SHS where just 27% of all households were families with children. The gender composition of the sample is similar to the SHS. The study population contained 47% females and 42% males, with 11% unknown. The SHS results show 52% females and 48% males. Finally, 66% of the survey population held an undergraduate or postgraduate degree. This compares to 14% of the SHS population who held a first or higher degree. Clearly, respondents were more highly educated than the general population and more likely to be from a household with children.

5.5.2 Diversity of respondents

Although results showed that, unsurprisingly, there were no anthropocentrics among respondents, the NEP results revealed 'shades of green' among the respondents, with 13% classed as weak ecocentrics, 39.5% strong ecocentrics and 39.5% very strong ecocentrics. This demonstrates that the target population should not be viewed as an homogenous group of environmental protesters, but a diverse group with different levels of concern about the environment.

5.5.3 Socio-demographic variables and the NEP scale

Previous studies using the NEP scale have suggested that there is a range of socio-demographic variables that are significant in determining a respondent's environmental values. Dunlap *et al* (2000) found that environmental concern was correlated with variables such as age, education, political party, occupational sector and others. Findings in this study revealed only that gender was related to the level of ecocentricity.

5.5.4 Relationship between risks and benefits

The results from the average values assigned to the four risk and benefit categories correspond with previous findings demonstrating that more people thought the risks of GM foods outweighed the benefits than vice versa (Poortinga & Pidgeon, 2003). Importantly, as current risks were valued lower than future risks and current benefits were valued more highly than future benefits, there is some suggestion of a relationship between risks and benefits. When risks are valued more highly, benefits are valued lower. Put another way, the greater the perception of risk, the smaller the perception of benefit, hence it could be argued that the claim, made for example by Alhakami and Slovic (1994), that there is an inverse relationship between risks and benefits is supported here.

5.5.5 Trust and survey responses

When the decision to target anti-GM and environment groups was taken, it was assumed that the level of knowledge and interest in the topic, by at least some of this population, would result in a good response. However, this was not the case. The degree of suspicion and scepticism of some of those targeted is evident from the comments received, as shown below:

> *"We feel it is in our interests to not aid you in your research. This is because; whatever your personal views on GM, the research that goes back to the policy makers will be used for the interests of promoting and furthering "scientific research" and in the interests of profit. Detailed information on the perception of those against GM can and are easily used to assist in greenwashing the GM industry".*
>
> *"They (other members of the group) didn't see how filling in the forms could benefit our cause, and were a bit suspicious of what the SE might use them for".*[8]
>
> *"How will the results be used?"*
> *"Considering GM nation has already taken place, what is the rationale for this study, and why is the Scottish Executive involved?"*
>
> *"I am really sorry to see public funds used in this way. The risks of the technology are sufficiently clear; the need for it sufficiently tenuous; and the commercial motivation sufficiently strong that I am really distressed at this attempt to find ways to discredit those opposed to it".*

These comments demonstrate a lack of trust in government and industry, a recognised social issue not restricted to the GM debate (see for example, Poortinga & Pidgeon, 2003). This distrust has, however, been especially notable in the GM debate and is particularly strong amongst the target population. The point is demonstrated by the fact that 42% of respondents believed there would be 'no' or 'very little' consideration of public opinion before decisions were made about commercialisation of GM crops.

[8] The research was funded by the Scottish Executive

5.5.6 Trust and belief in future benefits

The expectation was that the value of future benefits would be greater than current benefits, *if respondents believed the claims made about the future benefits of GM technologies*. This expectation was based on the claims by advocates of biotechnology that future GM technologies will present clearer consumer, environmental and social benefits. However, as noted above, current benefits were valued greater than future benefits. Thus it appears that the respondents to this study do not expect many of the claims made about the future benefits of GM technologies to materialise. Consider also the question "*to what extent do you think people in developing countries will benefit from the production of GM crops with added vitamins?".* Fifty percent of respondents said 'not at all' or 'very little'. Only 5% said 'some'. This corresponds with the scepticism and suspicion revealed by the comments noted above from non-respondents. Significantly, it reveals a pervasive lack of trust in those providing information about the future benefits of GM technologies.

5.5.7 Trust and the promise of environmental benefit

There have been claims that some environmentalists might be more inclined to accept some GM technologies if they believe that environmental benefits arise from the application of the technology (Isaacs, 2001). However, the responses to specific questions within the survey suggest this is unlikely to be the case amongst those most pro-environmental and/or anti-GM. If people do not believe these claims about GM technologies, they are unlikely to consider that they offer any environmental benefits. As regards the environmental benefits that GM technologies might offer *in the future*, a similar story is revealed. Again, this reveals a lack of trust in those bodies making claims about potential benefits of GM technologies.

5.5.8 Uncertainty and perceived health risks

There was a degree of consensus relating to questions about environmental impacts. In contrast, responses were more ambiguous regarding health risks. This suggests that respondents have largely made up their minds regarding GM and the environment, but are still unsure about the health effects. Indeed, results demonstrate a high degree of uncertainty relating to the issue of health risks of GM food.

5.5.9 Psychometric paradigm dimensions of risk

The results relating to the questions that were designed to address the psychometric paradigm items of control over exposure, predictability of impacts and distribution of impacts are largely unsurprising, given the target group. Thus, percentage responses to the questions indicate that generally respondents feel they have little control over exposure to perceived risks. Further, they believe that risks are unpredictable, and feel that benefits are most likely to accrue to the biotechnology companies, while the risks will impact farmers, consumers, and organic growers, both in Scotland and developing countries. All of these factors mean that risk perceptions, and thus resistance, are likely to remain high.

The findings that those who were living near to an FSE trial site value current and future benefits lower than those not living near to an FSE trial site suggest that heightened concern may have arisen out of closer personal experience of GM crops. These results are important. The results suggest that increased familiarity actually increases perceptions of risk (although this link was not proven directly). This latter finding contradicts one of the claims made by the psychometric paradigm theory stating that it is a lack of familiarity that leads to greater risk perception.

5.5.10 Factors related to perceptions of current and future risks and benefits

Findings here correspond with results from other surveys conducted with members of the general public that found that women considered GM food to be more risky than men (Subrahmanyan & Cheng, 2000; Moon & Balasubramanian, 2001). A study by Isaacs (2001) investigating acceptance of GM foods found no significant difference in willingness to buy or unwillingness to buy when considering many socio-demographic variables. The exception was that a larger portion of the ‘unwilling to buy’ sample were female than the ‘willing to buy’ sample. Results here confirm very few socio-demographic variables influenced perceptions of risk, with gender being one. Results here also reflect findings from other studies with the general population that the more highly educated consider risks to be lower (Moon & Balasubramanian, 2001; Gaskell *et al*, 2003).

Although not found to be related directly to perceptions of risk, the findings were that those who were living near to an FSE trial site value current and future benefits lower than those not living near to an FSE trial site. Also, those living in urban areas expressed a lower value for future risks than those in rural areas. These results may demonstrate the relevance of geographical contextual factors such as location.

Results revealed that the more strongly ecocentric respondents were, the greater they valued current risks. The study by Isaacs (2001) also used the NEP scale and found that those who opposed GM food were more ‘pro-environmental’ than those who supported it.

Overall, the statistical analysis conducted in this study confirmed the influence of a range of factors on perceptions of current and future risks associated with GM foods. To sum up, these are: gender, education, NEP group and place of residence. There was also some suggestion of interaction between NEP group and gender although this was only weakly significant.

5.6 Conclusions

The results make it possible to draw a number of conclusions regarding the construction of risk perceptions of anti-GM campaigners in relation to GM technology in food and agriculture. This chapter has shown that there is evidence of an inverse relationship between perceived risks and benefits. When benefits are expected to be greater, risks are expected to be smaller. This supports the hypothesis that risk perceptions are influenced by associated benefits.

Psychometric paradigm dimensions of risk that are shown to be important include the level of uncertainty regarding, for example, potential health risks. In addition, more familiarity with the technology, for example through being in close proximity to an FSE trial site, apparently decreased perceptions of benefits of GM food. Results also revealed a strong sense of lack of control over exposure to the technology, and little trust in authority to provide opportunity for greater control in the future.

A lack of trust was also revealed in other ways, namely, an absence of belief in claims of future benefits or environmental benefits, and the reluctance to be involved in the study at all.

Environmental attitudes were shown to affect the extent of risk perceptions, hence respondents who were more ecocentric also believed the technology presented greater risks.

As the results of this study show that anti-GM campaigners and members of environment groups can be segmented into groups with different perceptions of the risks and benefits of GM food, they should not be viewed as an homogenous group.

There were a number of socio-demographic and geographical (contextual) factors that were shown to be connected to risk perceptions, notably gender, education, location (rural or urban) and proximity to GM trial sites (the latter may be an indirect connection through benefit perceptions). There is evidence that, in some cases, women and those living in rural areas consider the risks of GM to be greater, and the benefits less, than men and people living in urban areas. There is also evidence that people living near to a FSE trial site expected the future benefits of GM technology to be less than those who were not living near an FSE trial site.

Another of the dimensions of risk thought to be particularly relevant to the issue of GM foods is the equity or distribution of risks and benefits. One reason often presented as an explanation as to why there has been so much resistance to GM crops in some countries, is that all the benefits are believed to accrue to biotechnology companies and some farmers, but not to consumers. Hence, the argument goes, why should consumers accept a new, unknown and therefore potentially risky technology, that does not offer them explicit benefits? Results to those questions designed to address the issue of distribution of impacts are largely predictable and demonstrate that respondents are sceptical about benefits accruing to Scottish consumers or people in developing countries, expect negative impacts to fall on organic farmers, and economic benefits to be experienced by biotechnology companies.

Overall, the results presented in this chapter demonstrate the importance of a range of the factors hypothesised to impact on perceptions of risk, when considering those in Scotland expected to demonstrate the greatest level of perceptions of risk about the technology. In the next chapter, consideration turns to Scottish farmers, a key group when considering the potential future of GM crops in Scotland.

Chapter 6: Investigating Scottish farmers' risk perceptions of genetically modified (GM) crops in Scotland

6.1 Introduction

The aims of this chapter were to investigate the perceptions of risk that Scottish farmers have towards GM technology in agriculture, and whether this might be related to certain farm business structural factors and farmer characteristics. In order to achieve the aims the objective was to conduct a postal survey with farmers in Scotland to discover what their intentions might be as regards adoption of the technology. As noted in chapter three it has long been recognised that there is a relationship between technology adoption and risk perceptions (Rogers, 1962).

6.2 Background

As discussed in chapter two, legislation covering the commercial planting of GM crops in Scotland is operational at the EU level, and member states cannot unilaterally decide to grow or ban a GM crop. Once a particular modified crop has been approved for commercial release under EU Deliberate Release Directive 2001/18, it is the decision of the farmer that will determine if and where that crop will be grown. Hence, understanding the level of risk perceptions that farmers have towards GM technology, and related to this, their intentions towards adoption of GM crops, is central to understanding how the adoption of GM technology might develop in agriculture in Scotland. As discussed in chapter three, there is a range of factors that have been identified in the literature as influencing the level of risk that farmers perceive. These include farmer age and education, and farm business characteristics such as enterprise type, size of farm, and ownership structure.

As risk perceptions are related to (potential) technology adoption decisions, it is useful also to consider the technology adoption literature. This literature reveals a similar range of variables thought to influence farmer decisions about technology adoption, as the variables thought to be related to risk perceptions (see chapter three).

The issue of technology adoption by farmers has been studied extensively, including, in a limited number of cases, the specific topic of adoption of GM technology. These studies have generally focused on identifying the structural characteristics of the farm business, or socio-demographic characteristics of the farmer, that are associated with adoption decisions. Thus there is a range of studies that have investigated the impact of, for example, farmer age, on adoption of GM technology in agriculture (Thirtle *et al*, 2003; Payne *et al*, 2003; Barham *et al*, 2004; Barham, 1996; Chimmiri *et al*, 2006). It has been found, for example, that older farmers are more likely to adopt first (Thirtle *et al*, 2003; Payne *et al*, 2003). However, Barham (1996) found that it was younger farmers who were likely to be first to adopt rBST (recombinant bovine somatotrophin) in milk production, and yet another study found that age had no statistically significant impact on choices relating to adoption of GM crops (Chimmiri *et al*, 2006). Another variable commonly investigated for its impact on GM technology adoption, is farm size or size of farm business (Thirtle *et al*, 2003; Payne *et al*, 2003; Qaim & de Janvry, 2003; Hategekimana & Trant, 2002; Chimmiri *et al*, 2006; Kondoh & Jussaume, 2006). In this case, larger farms are frequently found to be the ones where adoption occurs first (see for example, Thirtle *et al*, 2003; Payne *et al*, 2003; Qaim & de Janvry, 2003). Other factors investigated by previous studies include farmer education (Payne *et al*, 2003; Barham *et al*, 2004; Barham, 1996; Kondoh & Jussaume, 2006); crop management practices (Thirtle *et al*, 2003; Payne *et al*, 2003); chemical costs (Thirtle *et al*, 2003) and experience of crop losses to pests (Payne *et al*, 2003). Hence farmers with a higher level of education (Barham *et al*, 2004; Kondoh & Jussaume, 2006) and those who have previously suffered crop losses to pest problems for which GM crops are designed to be a solution (Payne *et al*, 2003), are more likely to be early adopters. Similarly, farmers previously inclined to adopt new technologies (such as hybrid crop varieties) have been found to be more likely to indicate future intention to adopt GM varieties (Kolady & Lesser, 2006).

Previous findings relating to both farmers' risk perceptions and technology adoption decisions have been used to inform the design of the survey reported here. The remainder of the chapter is structured as follows: The next section describes the methodology, detailing the structure of the survey, and the approach taken for analysis. This is followed by presentation of results from the survey, and analysis, which in turn are followed by discussion of the key findings and conclusions.

6.3 Method

In 2005 a postal survey was distributed to 400 farmers across four regions of Scotland (north east, north west, south east and south west) (see appendix five for full survey). The regions used are those designated by the (then) Scottish Executive for their Economic Report on Scottish Agriculture (Scottish Executive, 2007) and are as shown in figure 6.1. This was the only stratification that was applied to the survey sample.

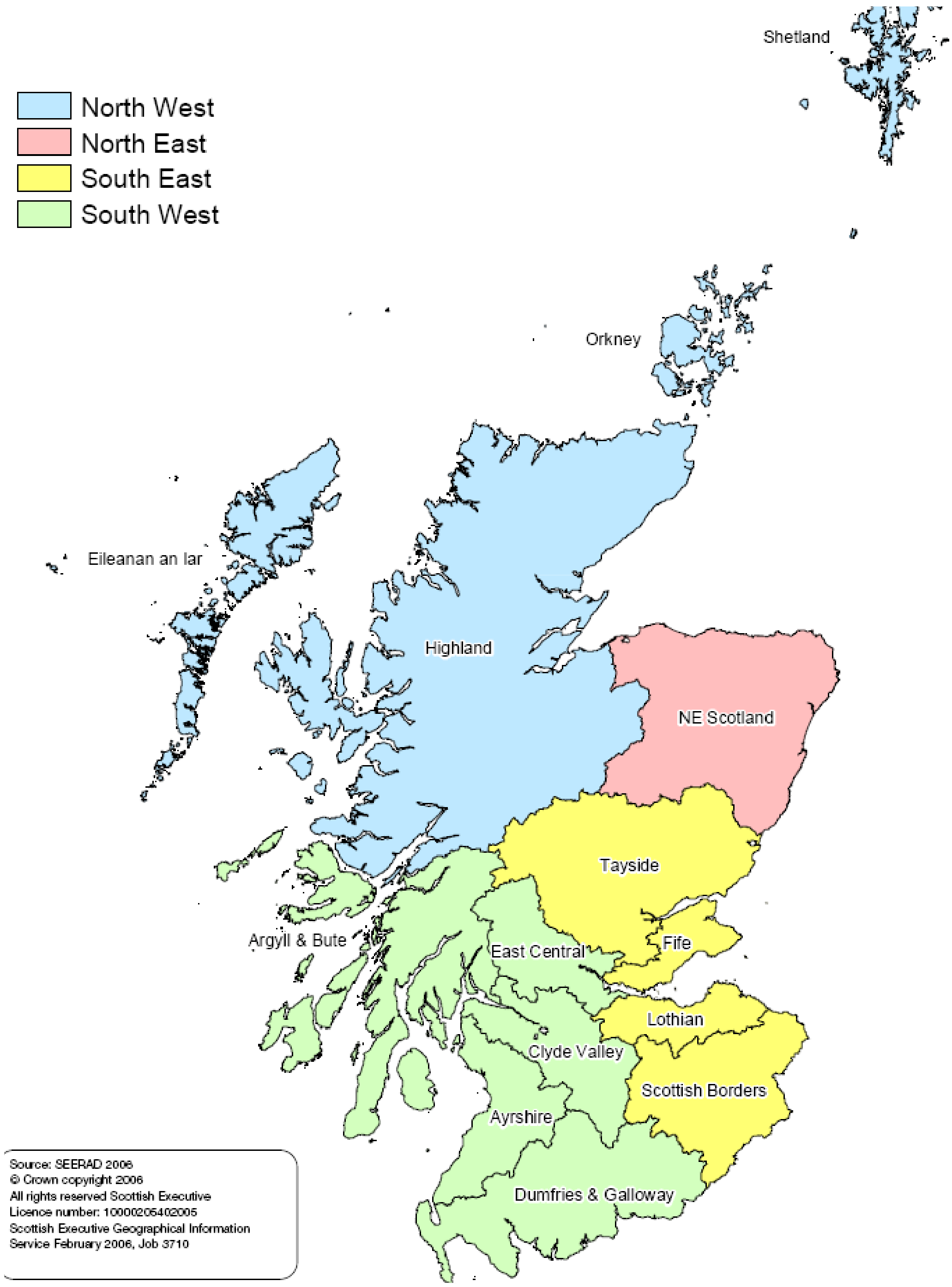

Figure 6.1 Scottish Regions
Source: Scottish Executive, 2007. Economic report on Scottish agriculture, 2007 edition. Scottish Executive, Edinburgh

The survey featured a question relating to the intention or not to adopt GM crops, and a number of socio-demographic questions, for example, age of farmer and number of years farming. In addition, there were questions relating to the farm business, such as whether or not the farmer took over management of the farm from a previous generation of the family, and the main crops currently being cultivated.

The potential adoption question was as follows: "*A number of genetically modified crops have already been approved for cultivation in the European Union but are not currently grown in the UK. Some predictions are that the first commercial cultivation of genetically modified crops in the UK is not likely until perhaps 2008. If a genetically modified variety of the main crop(s) you currently produce was/were to be available for commercial planting in 2008 would you choose to grow it/them or not?*". Farmers were offered three response options: 'Yes', 'no' or 'don't know', and were asked for the reasons for their response.

As technology adoption decisions are related to levels of risk perception, in the analysis the three adoption categories were assigned to a risk perception scale. Thus, 'Yes – would adopt GM crops' was taken to equal small perceived risk, that is, the farmers with this score perceived the risks of the technology to be low (score of one); 'Don't know if I would adopt GM crops' was taken to equal a medium perception risk (score of two); and 'No – would not adopt GM crops' was taken to equal a high perceived risk when considering GM crops (score of 3). Hence instead of asking for a self-defined level of risk perception relating to GM technology, the potential adoption decision response was taken to be a proxy for the extent to which the technology is perceived by the farmer to be risky.

Previous studies have used a range of approaches as a means of uncovering respondents' risk perceptions. Wilson *et al* (1993) asked farmers to rank a number of farm business factors, in terms of the level of risk and uncertainty that they (the farmer) considered to be associated with those factors. The study takes a similar approach to the study reported in chapter five of this thesis and would have been a valid approach for the work conducted with farmers in this study. However, in order to broaden the methodological scope used throughout the thesis, the decision was taken to adopt a different approach. In addition, the adoption question was considered to be a more straightforward question for farmers to respond to. Further, as was demonstrated above, the literature on both farmers' risk perceptions, and technology adoption decisions, reveals similar variables to be influential. Thus it was considered a valid approach to use a potential adoption decision as a proxy for level of perceived risk associated with the technology.

As well as the potential adoption question, and the socio-demographic questions, the survey contained 13, mainly open-ended, questions designed specifically to elicit opinion statements. For example, farmers were asked "*What do you think will be the main advantages (if any) arising from the introduction of genetically modified crops in Scotland*?". The aim in collecting these statements was to provide the discourse necessary to conduct a Q methodology study. This is reported in chapter seven. The results reported in chapter seven reveal the complex nature of both risk and benefit perceptions relating to GM crops, and hence further support the decision not to ask farmers a direct question such as "how risky do you think GM crops are?" or "do you perceive GM crops to have high/medium/low level of risk?".

Analysis of the results from the postal survey was conducted using T tests and ANOVA. The aim of this was to investigate which variables (if any) were related to the level of perceived risk towards the technology. This was followed by attempts to investigate interaction between variables, using two way ANOVA, and the effect of inclusion of a co-variate using ANCOVA.

6.4 Results

The postal survey was returned by 51 farmers from the four regions of Scotland. To be representative by region the percentage needed to be 33% from the south east, 17% from the south west, 28% from the north east, and 22% from the north west, these being the proportion of relevant farm types in each region. Of the responses, 43% were from the south east, 8% were from the south west, 22% were from the north east, and 23% were from the north west, with 4% unknown. Hence the south east is over-represented in the responses, and the south west under-represented, with the north west and north east regions being largely representative.

6.4.1 Respondent details

The typical respondent has a farm of 200-299ha (71% of respondents) (table 6.1). This compares to Scottish Executive data stating that the average farm size is 174ha (RERAD, 2007), so respondent farms are slightly larger than average. Typically, respondent farmers are farm owners (67%), not tenants. This is largely consistent with the situation across Scotland where approximately 70% of all farm holdings are owner occupied (Duke of Buccleuch, 2003). An overwhelming 94% of respondents were male, and on average between 50-59 years old (33%). The latter is in line with the situation in farming across the UK where the average age of farmers is 57 (The Scottish Parliament, The Information Centre, 2000). A reflection of the average age is found in the fact that the average respondent has been farming for 30-39 years (31% of respondents). Assuming that the majority began farming in their twenties, age and years in farming can be taken to be proxies for each other. The majority of respondents took over management of the farm from a previous generation of their family (71%) but typically were not certain whether they would pass on management of the farm to the next generation of their family (53% said they may, 14% said no and only 31% said yes (2% no response)). The figure of 71% reflects findings from a recent survey with agricultural students in Scotland where 70% of respondents were from a family farm (Maxwell, 2007). However, the fact that only 31% were sure they would pass on the farm to the next generation of their family is not borne out by results from the same survey. Here 72% of those who were from a family farm stated that they intend to return home at some point. Of the 72% who intend to return home, 82% of these intend to take over succession of the family farm (Maxwell, 2007). The findings from Maxwell's study, if reflected in the findings from the current study, ought to mean that a far greater percentage of respondents would be expecting to pass the farm on to the next generation. It may be that families have not discussed the issue, hence farmers are unaware of their off-springs' intentions, or it may be that the intentions of offspring are not always followed through in the long term. Respondents were also asked to list the main crop or crops that they were cultivating. Results are as follows: 65% of respondents, barley; 41% grass; 26%, wheat and 26%, other, unspecified cereal crops. Twenty percent were cultivating oilseed rape (OSR), 18% vegetables, 18% potatoes, 4% fruit and 4% other crops. Almost all were cultivating a combination of these.

Table 6.1 Respondents

VARIABLE	CATEGORIES	PERCENTAGE OF RESPONDENTS
Farm size	0-299ha	71
	300-599ha	22
	600ha and over	6
	No response	1
Ownership status	Owner	67
	Tenant	12
	Both owner and tenant	18
	No response	3
Sex	Male	94
	Female	4
	No response	2
Age	30-39	14
	40-49	20
	50-59	33
	60-69	26
	70 or over	6
	No response	1
Number of years farming	10-19	8
	20-29	28
	30-39	31
	40-49	24
	50 years or more	8
	No response	1
Did you take over farm from previous generation?	Yes	71
	No	28
	No response	1
Will you pass on farm to next generation of family?	Yes	31
	No	14
	Maybe	53
	No response	2
Main crops being cultivated	Barley	65
	Grass	41
	Wheat	26
	Cereal crop (unspecified)	26
	OSR	20
	Vegetables	18
	Potatoes	18
	Fruit	4
	Other crops	4

6.4.2 Results from GM adoption decision question

In responding to the question "*If a GM variety of the main crop(s) you currently produce was / were to be available for commercial planting in 2008 would you choose to grow it / them or not*?", only 12% of respondents said 'yes' they would, 33% said 'no' they would not, and more than half of all respondents (55%) stated that they 'don't know'. As noted in the methodology section, the three response categories were assigned to a risk perception scale of 1-3. The aim was to investigate the extent to which the degree of perceived risk could be said to be related to a range of socio-demographic and farm business structural factors. Thus T tests and ANOVA analysis were conducted of the mean values associated with each of the variables in order to test for statistical significance between the means. Results are as shown in table 6.2.

Findings show the following. Barley growers have greater perceived risk than those who are not barley growers (p value 0.027). Potato growers have lower perceived risk than those who are not potato growers (p value 0.014). Growers of ‘other’ crops have lower perceived risk than those who do not grow ‘other’ crops (p value 0.02). Farmers who are either solely tenant farmers or solely farm owners have higher perceived risk than those who are both tenants and owners (p value 0.023). Males have higher perceived risk than females (p value 0.02). Farmers who think GM is good have lower level of perceived risk than those who do not think GM is good (p value 0.039). Farmers who think GM is bad, have higher level of perceived risk than those who do not think GM is bad (p value 0.104). None of the other variables were found to be significantly related.

Table 6.2 T tests and Anova Level of perceived risk

Variable	Mean values[1]					T-test statistic	Degrees of freedom	F-statistic	P-value
Grow barley									
	No	Yes							
	1.94	2.36				-2.275	48	-	0.027**
Grow wheat									
	No	Yes							
	2.16	2.38				-1.066	48	-	0.292
Grow grass									
	No	Yes							
	2.24	2.19				0.272	48	-	0.787
Grow vegetables									
	No	Yes							
	2.27	2.00				1.128	48	-	0.265
Grow OSR									
	No	Yes							
	2.25	2.10				0.651	48	-	0.518
Grow fruit									
	No	Yes							
	2.21	2.50				-0.620	48	-	0.538
Grow cereals									
	No	Yes							
	2.28	2.00				1.283	48	-	0.206
Grow potatoes									
	No	Yes							
	2.29	1.89				2.627	25	-	0.014*
Grow other crops									
	No	Yes							
	2.23	2.00				2.405	47	-	0.02**
Sex									
	Female	Male							
	2.00	2.23				-2.405	47	-	0.02**
Take over farm from family?									
	No	Yes							
	2.21	2.22				-0.038	48	-	0.969
Think GM is good									
	False	True							
	2.34	1.93				2.119	48	-	0.039**
Think GM is bad									
	False	True							
	2.12	2.44				-1.657	48	-	0.104***
Don't know if GM good or bad									
	False	True							
	2.19	2.26				-0.410	47.9	-	0.684
Age group									
	30-39	40-49	50-59	60-69	70 +				
	2.14	2.10	2.35	2.15	2.33	-	-	0.327	0.858
Will pass on?									
	Yes	No	Maybe						
	2.19	2.57	2.15			-	-	1.226	0.303
Region									
	SE	SW	NE	NW	Unknown				
	2.09	2.75	2.18	2.17	3.00	-	-	1.711	0.164
Years in farming									
	10-19	20-29	30-39	40-49	50+				
	2.25	2.00	2.31	2.25	2.50	-	-	0.661	0.622
Farm size									
	0-299ha	300-599ha	600ha +						
	2.30	2.09	1.67			-	-	1.67	0.199
Ownership status									
	Owner	Tenant	Both	Unknown					
	2.32	2.33	1.67	3		-	-	3.479	0.023**

* Significant at 0.01 level; ** Significant at 0.05 level; *** Significant at 0.10 level;

[1] 1=Low level of perceived risk; 2=Medium level of perceived risk; 3=High level of perceived risk

6.4.3 Testing for interaction

One way ANOVA and T tests gave some indication of what was explaining mean values of risk perception among farmers. However these analyses do not look for interaction between variables. Therefore, the intention was to conduct two way ANOVA in order to investigate this. During the one way ANOVA and T tests procedures, each independent variable was examined individually to assess its potential importance separately. In the two way ANOVA procedure those variables that were found to be significant in the one way ANOVA and T tests were retained and re-examined to explore any relationships between the variables.

As noted, a total of seven variables was found to be significant when conducting T tests and one way ANOVA. These were: whether or not the farmer grew barley as a main crop; whether or not the farmer grew potatoes as a main crop; whether or not the farmer grew ‘other crops’ as a main crop; the sex of the respondent; whether the farmer thought that GM would be good for Scottish agriculture; whether the farmer thought GM would be bad for Scottish farming; and what the ownership status was of the farm.

These seven variables produced 21 potential combinations of pairs of variables. However, with some pairs of variables there was no logical reason to test for interaction. For example, there was no reason to test for interaction between ‘think GM will be good’ and ‘think GM will be bad’. Therefore, the intention was to run two way ANOVA with 17 different factorial designs, in various combinations of pairs of these variables. However, missing values proved to be an issue for this analysis. It was not possible to examine interactions between the following pairs: barley and gender because there were no values for females growing barley; potatoes and gender because there were no values for females growing potatoes; ‘other crops’ and gender because there were no values for females growing other crops; ‘other crops’ and ‘think GM is good’ because there were no values for those growing other crops who thought GM would be good; ‘other crops’ and ‘think GM is bad’ because there were no values for those growing other crops who thought GM would be bad; ‘other crops’ and ownership status because all of those growing other crops are in the same ownership status category (owner); or gender and ‘think GM is good’ because there were no values for females who thought GM would be good.

Thus two way ANOVA was conducted with 10 different factorial designs to investigate the following questions: “is there a ‘barley’ by ‘think GM will be good’ interaction?”; “is there a ‘barley’ by ‘think GM will be bad’ interaction?”; “is there a ‘barley’ by ‘status’ interaction?”; “is there a ‘potatoes’ by ‘think GM will be good’ interaction?”; “is there a ‘potatoes’ by ‘think GM will be bad’ interaction?”; “is there a ‘potatoes’ by ‘status’ interaction?”; “is there a ‘gender’ by ‘think GM will be bad’ interaction?”; “is there a ‘gender’ by ‘status’ interaction?”; “is there a ‘status’ by ‘think GM will be good’ interaction?”; and “is there a ‘status’ by ‘think GM will be bad’ interaction?”. Note, status here refers to ownership status of the farm.

No interaction effects were revealed by two way ANOVA for any of these pairs of variables. P values for the interactions were as follows: barley and ‘think GM will be good’ (0.791); ownership status and think GM will be good (0.125); barley and think GM will be bad (0.417); ownership status and think GM will be bad (0.563); ownership status and barley (0.476); ownership status and potatoes (0.441); potatoes and think GM will be good (0.870); potatoes and think GM will be bad (0.755); gender and think GM will be bad (0.714); gender and ownership status (0.436).

It was decided to conduct ANCOVA to investigate a number of these variables further.

6.4.4 ANCOVA

Analysis of covariance (ANCOVA) is used to test the main effect and interaction effect of independent variables on the dependent variable, while controlling for the effect of another variable which co-varies with the dependent variable (Garson, 2009). The control variable is therefore called the ‘covariate’. ANCOVA uses built-in regression using the covariate to predict the dependent variable, then performs ANOVA to see if the factors are still significantly related to the dependent variable after the variation due to the covariate has been accounted for. ANCOVA is used to remove the effect of a variable which modifies the relationship of the categorical independent variables with the dependent variable and thereby to reduce the error term in the model. In this study ‘think GM will be good’ was entered as a co-variate, as changes in the value of this variable can be expected to be associated with changes in the value of the dependent variable, risk perception value.

Three models were run, each with ‘think GM will be good’ as the co-variate, to test the impact of ‘growing barley as a main crop’, ‘growing potatoes as a main crop’ and ‘ownership status’ on the dependent variable, ‘risk perception value’.

Growing barley as a main crop

The first step was to produce a model which tested whether there was an interaction between the factor 'barley' and the covariate 'gm will be good'. The significance value of the interaction term is greater than 0.10, which shows it is not important. Further, the partial eta squared term is near 0, showing it accounts for a negligible amount of variation compared to the error term (table 6.3). These results mean that it can be assumed that there is homogeneity of the coefficient for the covariate across the levels of the factor. This is the required result and analysis can proceed.

Table 6.3 Tests of between-subjects effects: Barley and think GM will be good

SOURCE	TYPE III SUM OF SQUARES	DF	MEAN SQUARE	F	SIG.	PARTIAL ETA SQUARED
Corrected Model	3.824[a]	3	1.275	3.500	.023	.186
Intercept	164.087	1	164.087	450.471	.000	.907
barley	1.230	1	1.230	3.377	.073	.068
gm_good	1.739	1	1.739	4.775	.034	.094
barley * gm_good	.026	1	.026	.071	.791	.002
Error	16.756	46	.364			
Total	267.000	50				
Corrected Total	20.580	49				

a. R Squared = .186 (Adjusted R Squared = .133)

Next the procedure was to produce an analysis of covariance to assess the effect on risk perception values of being a barley grower, controlling for the extent to which the respondent believes GM technology will be good for Scottish agriculture. The descriptive statistics table shows a difference in the level of risk perception (table 6.4). There is a slight difference in the standard deviations.

Table 6.4 Descriptive statistics: Barley

BARLEY	MEAN	STD. DEVIATION	N
No	1.9412	.65865	17
Yes	2.3636	.60302	33
Total	2.2200	.64807	50

The significance value of Levene's test is greater than 0.05, which suggests that the equal variances assumption is not violated (table 6.5).

Table 6.5 Levene's test of equality of error variances

F	df1	df2	Sig.
.799	1	48	.376

a. Design: Intercept + gm_good + barley

The spread-versus-level plot is useful in testing the homogeneity of variances assumption, and in identifying cells which deviate substantially from the assumption (Garson, no date). The spread-versus-level plot shows what appears to be a relationship between the mean and standard deviation, but due to the small number of groups, this is inconclusive (figure 6.2).

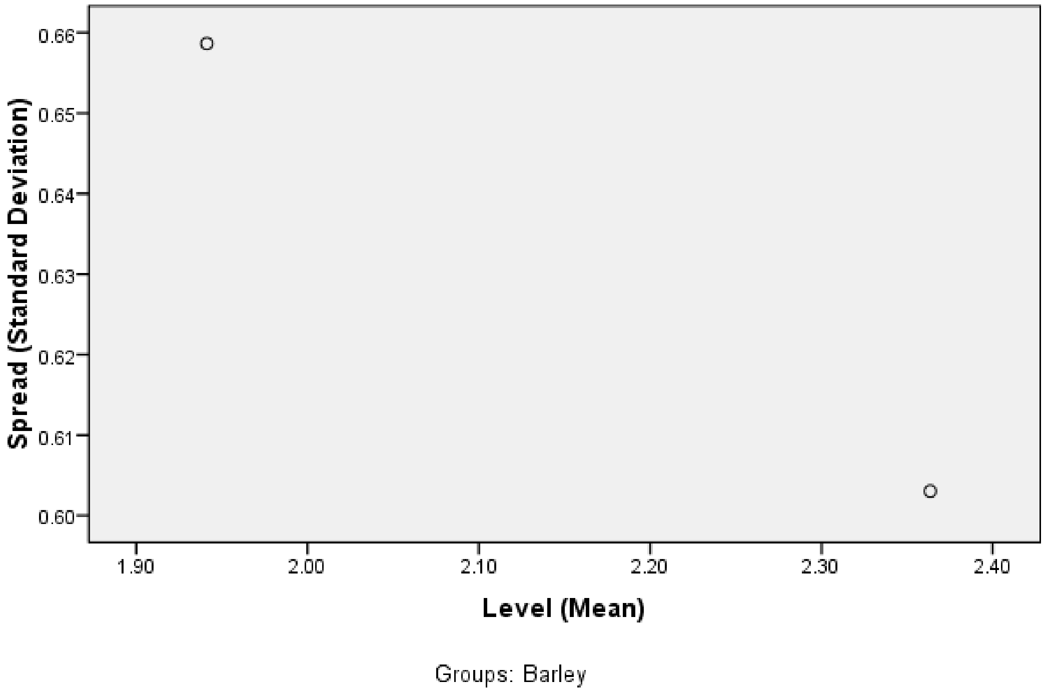

Figure 6.2 Spread versus level plot of risk perception value: Barley

Since the difference in spread, about 0.06, is small with respect to the difference in level, about 0.5, it is probably safe to assume that the variances are homogenous across groups.

The significance value for barley growing is less than 0.05, indicating it has a significant effect on risk perception (table 6.6). The parameter estimates help to determine the size of that effect.

Table 6.6 Tests of between-subjects effects: Barley and think GM will be good

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3.798[a]	2	1.899	5.319	.008	.185
Intercept	168.322	1	168.322	471.415	.000	.909
gm_good	1.796	1	1.796	5.030	.030	.097
barley	2.037	1	2.037	5.706	.021	.108
Error	16.782	47	.357			
Total	267.000	50				
Corrected Total	20.580	49				

a. R Squared = .185 (Adjusted R Squared = .150)

The parameter estimates show the effect of each predictor on risk perception (table 6.7) . The value of –0.426 for [barley=0] indicates that, given two people with similar attitudes as regards whether GM will be good for Scottish agriculture, the risk perception of a non-barley grower can be expected to be less than that of a barley grower. Remember that the risk perception scale runs from 1 (low risk perception) to 3 (high risk perception). The non-barley grower is therefore likely to have a risk perception score of 0.426 less than a barley grower.

Table 6.7 Parameter estimates: Barley and think GM will be good

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound	Partial Eta Squared
Intercept	2.489	.118	21.079	.000	2.251	2.727	.904
gm_good	-.414	.184	-2.243	.030	-.785	-.043	.097
[barley=0]	-.426	.178	-2.389	.021	-.785	-.067	.108
[barley=1]	0[a]	.	.	.	.	.	.

a. This parameter is set to zero because it is redundant.

To sum up, by specifying an interaction between the covariate and factor, it was possible to test the homogeneity of the covariate parameter estimates across levels of the factor. Since the interaction term was not significant, indicating the covariate parameter estimates are homogenous, it was possible to proceed with an analysis of covariance. It was found that growing barley increases risk perception as measured on a three point scale by 0.426, on average.

Growing potatoes as a main crop

Next, the same tests were run to further investigate the impact of growing potatoes on perceptions of GM risk. The first step was to produce a model which tested whether there was an interaction between the factor 'potatoes' and the covariate 'gm will be good'. The significance value of the interaction term is greater than 0.10, which shows it is not important. Further, the partial eta squared term is near 0, showing it accounts for a negligible amount of variation compared to the error term (table 6.8). These results mean that it can be assumed that there is homogeneity of the coefficient for the covariate across the levels of the factor. This is the required result and analysis can proceed.

Table 6.8 Tests of between-subjects effects: Potatoes

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2.879[a]	3	.960	2.494	.072	.140
Intercept	96.851	1	96.851	251.687	.000	.845
potatoes	.851	1	.851	2.212	.144	.046
gm_good	.904	1	.904	2.348	.132	.049
potatoes * gm_good	.010	1	.010	.027	.870	.001
Error	17.701	46	.385			
Total	267.000	50				
Corrected Total	20.580	49				

a. R Squared = .140 (Adjusted R Squared = .084)

Next the procedure was to produce an analysis of covariance to assess the effect on risk perception values of being a potato grower, controlling for the extent to which the respondent believes GM technology will be good for Scottish agriculture. The descriptive statistics table shows a difference in the level of risk perception (table 6.9). There is also a slight difference in the standard deviations.

Table 6.9 Descriptive statistics: Potatoes

Potatoes	Mean	Std. Deviation	N
No	2.2927	.67985	41
Yes	1.8889	.33333	9
Total	2.2200	.64807	50

The significance of Levene's test is under 0.05, which suggests that the equal variances assumption is violated (table 6.10). However, since there are only two cells defined by combinations of factor levels, this is not really a conclusive test.

Table 6.10 Levene's test of equality of error variances

F	DF1	DF2	SIG.
13.344	1	48	.001

a. Design: Intercept + gm_good + potatoes

The spread-versus-level plot (figure 6.3) shows what appears to be a relationship between the mean and standard deviation, but due to the few number of groups, this is inconclusive.

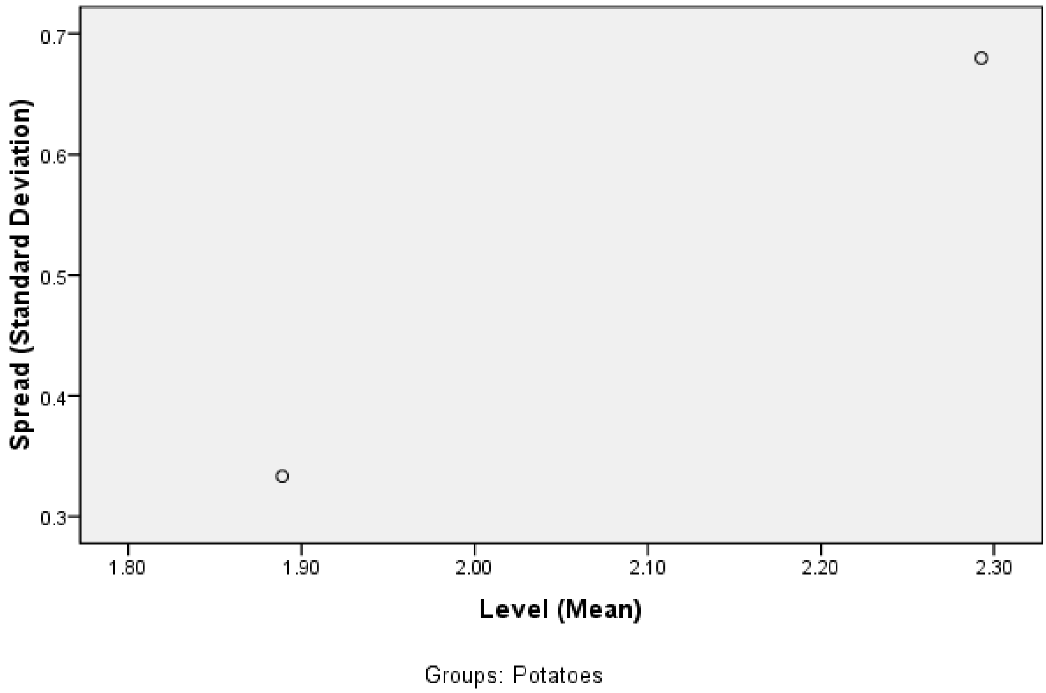

Figure 6.3 Spread versus level plot for value of risk perception: Potatoes

Since the difference in spread, about 0.35, is small with respect to the difference in level, about 2.4, it is probably safe to assume that the variances are homogenous across groups.

The significance value for growing potatoes as a main crop is less than 0.1, indicating it has a significant effect on risk perception values at the 90% level (table 6.11).

Table 6.11 Tests of between-subjects effects: Potatoes

SOURCE	TYPE III SUM OF SQUARES	DF	MEAN SQUARE	F	SIG.	PARTIAL ETA SQUARED
Corrected Model	2.868[a]	2	1.434	3.806	.029	.139
Intercept	113.577	1	113.577	301.390	.000	.865
gm_good	1.665	1	1.665	4.418	.041	.086
potatoes	1.107	1	1.107	2.939	.093	.059
Error	17.712	47	.377			
Total	267.000	50				
Corrected Total	20.580	49				

a. R Squared = .139 (Adjusted R Squared = .103)

The parameter estimates help to determine the size of that effect by showing the effect of each predictor on risk perception values (table 6.12). The value of 0.388 for [potatoes=0] indicates that, given two people with similar attitudes as to whether GM will be good for Scottish agriculture, it can be expected that the perception of risk value of the non-potato grower will be 0.388 higher on the risk perception scale than that of the potato grower.

Table 6.12 Parameter estimates: Potatoes

PARAMETER	B	STD. ERROR	T	SIG.	95% CONFIDENCE INTERVAL Lower Bound	Upper Bound	PARTIAL ETA SQUARED
Intercept	2.022	.214	9.440	.000	1.591	2.453	.655
gm_good	-.398	.190	-2.102	.041	-.780	-.017	.086
[potatoes=.00]	.388	.226	1.714	.093	-.067	.842	.059
[potatoes=1.00]	0[a]	.	.	.	.	.	.

a. This parameter is set to zero because it is redundant.

Ownership status

Finally, ANCOVA was conducted in order to investigate the relationship between ownership status and GM risk perception. The first step was to produce a model to test whether there was an interaction between the factor ‘ownership’ and the covariate ‘gm will be good’. The significance value of the interaction term is greater than 0.1, which shows it is not important. Further, the partial eta squared term is less than 0.1, showing it accounts for a negligible amount of variation compared to the error term (table 6.13). These results mean that it can be assumed that there is homogeneity of the coefficient for the covariate across the levels of the factor. This is the required result and analysis can proceed.

Table 6.13 Tests of between-subjects effects: Ownership status

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	6.401[a]	6	1.067	3.235	.010	.311
Intercept	92.853	1	92.853	281.594	.000	.868
status	1.782	2	.891	2.702	.078	.112
gm_good	2.227	1	2.227	6.754	.013	.136
status * gm_good	1.441	2	.720	2.185	.125	.092
Error	14.179	43	.330			
Total	267.000	50				
Corrected Total	20.580	49				

a. R Squared = .311 (Adjusted R Squared = .215)

Next the procedure was to produce an analysis of covariance to assess the effect on risk perception values of ownership status, controlling for the extent to which the respondent believes GM technology will be good for Scottish agriculture. The descriptive statistics table shows a difference in the level of risk perception (table 6.14). There is a slight difference in the standard deviations.

Table 6.14 Descriptive Statistics: Ownership status

Status	Mean	Std. Deviation	N
Owner	2.3235	.58881	34
Tenant	2.3333	.81650	6
Both	1.6667	.50000	9
No response	3.0000	.	1
Total	2.2200	.64807	50

The significance of Levene's test is greater than 0.05, which suggests that the equal variances assumption holds (table 6.15).

Table 6.15 Levene's test of equality of error variances

F	df1	df2	Sig.
2.145	3	46	.107

a. Design: Intercept + gm_good + status

The spread-versus-level plot does not appear to show a relationship between the mean and standard deviation (figure 6.4).

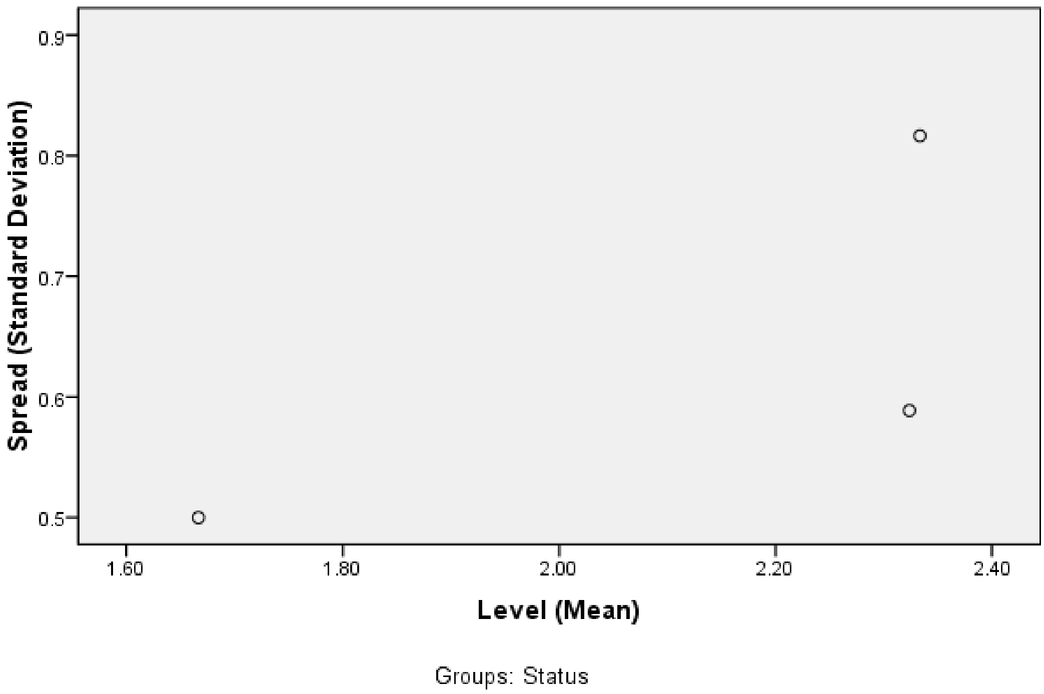

Figure 6.4 Spread versus level plot for risk perception value: Ownership status

The significance value for ownership status is less than 0.05, indicating it has a significant effect on risk perception values (table 6.16).

Table 6.16 Tests of between-subjects effects: Ownership status

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	4.960[a]	4	1.240	3.573	.013	.241
Intercept	58.184	1	58.184	167.628	.000	.788
gm_good	1.155	1	1.155	3.327	.075	.069
status	3.199	3	1.066	3.073	.037	.170
Error	15.620	45	.347			
Total	267.000	50				
Corrected Total	20.580	49				

a. R Squared = .241 (Adjusted R Squared = .174)

The parameter estimates help to determine the size of that effect (table 6.17). The value of –1.491for [status=3] (this ownership status is both owner and tenant) indicates that, given farmers with similar attitudes as to whether GM will be good for Scottish agriculture, it can be expected that the perception of risk value of the farmer who is both an owner and tenant will be the lowest of the ownership groups.

Table 6.17 Parameter estimates: Ownership status

PARAMETER	B	STD. ERROR	T	SIG.	95% CONFIDENCE INTERVAL Lower Bound	Upper Bound	PARTIAL ETA SQUARED
Intercept	3.355	.620	5.407	.000	2.105	4.604	.394
gm_good	-.355	.195	-1.824	.075	-.747	.037	.069
[status=1.00]	-.948	.616	-1.539	.131	-2.188	.293	.050
[status=2.00]	-.962	.657	-1.465	.150	-2.285	.360	.046
[status=3.00]	-1.491	.627	-2.378	.022	-2.754	-.228	.112
[status=99.00]	0[a]	.	.	.	.	.	.

a. This parameter is set to zero because it is redundant.

6.5 Discussion of results

The 51 returned surveys represented a response rate of 13%. One reason for the response rate is likely the nature of the survey instrument, and the inclusion of the open-ended questions. Thirteen questions of this nature, each with an associated box in which to write a considered response (rather than ticking boxes) may have deterred some farmers from responding. Ideally, the total design method (Dillman, 1978) of postal survey administration would have been followed, whereby a second follow-up mailing would have been undertaken after two weeks, to non-respondents. However, available time and resources meant that this was not possible.

Through T tests and ANOVA, a number of variables have been found to be significantly related to levels of perceived risk associated with GM crops: Farm ownership status, enterprise type, overall attitude to GM crops, and gender. Investigation using two way ANOVA failed to find evidence of interaction between variables. ANCOVA confirmed the importance of enterprise type and ownership status on risk perception values while controlling for the extent to which respondents thought GM would be good for Scottish agriculture.

Farmers with the lowest level of perceived risk associated with GM crops (and thus more likely to adopt) are less likely to be solely a farm owner or solely a farm tenant, less likely to grow barley as a main crop, more likely to grow other, unspecified types of crops, or potatoes, and, unsurprisingly, are more likely to think that GM will be good for Scottish agriculture. They are also more likely to be female although gender results should be treated with caution because only 6% of respondents were female.

Possible explanations for the significance of these variables follow. First, being both owner and tenant means that any risk and responsibility can be spread between the two aspects of the farm business. Hence if there are risks either to the tenancy side or ownership side of the farm business there are other options. This may create a tendency to consider that new ventures (for example farm management approaches or new technologies) are less risky for the farm business. This idea that diversity in the structure of the farm business may be related to levels of perceived risk is supported by a study by Meuwissen *et al* (2001). They found that insurance as a risk management strategy was perceived to be less relevant by mixed farmers, suggesting that diversity in the structure of the farm business may reduce perceptions of risk. Also, they found that farmers with a form of business partnership perceived insurance as less relevant than their colleagues with opposite characteristics. A relevant finding from the farmer GM technology adoption literature reveals that those farmers with non-farm income were also likely to be first adopters (Thirtle *et al,* 2003).

As noted, in some cases, the crops currently being cultivated by the farmer are related to level of perceived risk. As discussed in chapter three, previous studies have found that enterprise type affects risk perceptions (for example, Meuwissen *et al*, 2001; Flaten *et al*, 2005). The findings here confirm that. The fact that barley growers perceive the technology to be of greater risk is significant, and may relate to the importance of barley to the malting industry in Scotland. Growers will be conscious of the importance of quality and tradition to the industry, factors likely to lead to a greater perception that new technologies such as GM may present a risk and damage the image of the industry.

The possible need for caution towards the use of GM in the malting barley industry is an issue that has received attention from a variety of sources. For example, it has been reported that the Scotch Whisky Association advocated segregation to enable them to choose more easily whether or not to use GM raw materials. This suggests a level of unease towards the technology and the impact its use might have on the industry (House of Lords Select

Committee on European Communities, 1998). In addition, a Highland councillor actively lobbied for the Highland Council region to be declared a GM-free region, stating that "*our whisky distillers advertise the image of wind-swept hillsides, peat fires, clear, cold rivers and grain produced by small family-farms*". He continued "*imagine, then, how alien the concept of genetically modified crops is to the purchasers of our produce*" (Caithness News Bulletins, 2004). Scottish Genetix Action clearly stated their position, saying that "*Scotch whisky is a quality product renowned for being made from natural ingredients. We believe that genetic contamination of whisky would not be accepted by consumers and would damage the image and the integrity of the industry throughout the world*"(Scottish Genetix Action, no date). Further, Scottish National Party MSP Rob Gibson also expressed concerns about the possible impact of GM technology on the image of Scotch whisky. He questioned: "*How would people view Scotch Whisky if they thought the barley was contaminated with GM*?" (Holyrood Communications, 2006).

Potato growers express a lower level of risk perception. There may be a number of explanations for this. First, potato cultivation involves high levels of chemical use. Hence, modifications such as pesticide-expressing crops might offer significant benefits to farm management practices, great enough to outweigh the potential risks (in the minds of farmers). Second, GM potatoes are one of the crops where commercialisation is possible in the near future. Field trials have been approved in England for a blight resistant variety, and the EU has recently approved a modified starch potato for cultivation. Farmers may also be aware that GM potatoes were grown commercially in the USA for a number of years in the late 1990s.

A willingness to embrace alternative crops such as lupins suggests that the farmer generally perceives new farm management ventures as less risky and is thus more likely to embrace new alternative crops and technologies, including GM crops. However, as with gender variable the latter results should be viewed with caution because of the small number of respondents in one category.

Finally, the fact that overall attitude to GM crops (having the opinion that GM technology will either be good or bad for Scottish agriculture) is significantly related to the perceived level of risk, is an important finding, emphasising the relevance of attitudes in addition to structural business and personal characteristics.

6.6 Conclusions

Results have revealed that a range of factors discussed in chapter three, influence farmers' perceived level of risk in relation to GM technology, and their potential adoption decisions relating to GM crops. Importantly, results show that in this study it is the farm business characteristics such as ownership status and crops grown, rather than the personal characteristics of the farmers, that are more significant to the level of risk perceptions.

As shown, only 12% of respondents perceive a low level of risk, with 55% perceiving a medium level of risk, and 33% a high level of risk. This demonstrates a high degree of caution amongst the farmers in the study towards GM crops in Scotland. This caution appears to be strongly linked to uncertainty as the majority stated that they did not know whether they would adopt GM crops. Reasons given included statements such as:

> *"I don't know because of the lack of information";*
> *"I will wait and see what happens";*
> *"I need to see results from more trials";*
> *"It depends on public opinion";*
> *"I would rather wait for other farmers to try it first"; and*
> *"I need to be convinced it's safe".*

This is important because, as discussed in chapter three, uncertainty is thought to be important to perceptions of risk, and this is clearly demonstrated here.

As noted, attitude to GM technology – specifically, whether the farmer thought it would be good or bad for Scottish agriculture – was found to be significantly related to risk perceptions. This is important because it suggests that consideration of business and personal characteristics may not be sufficient to explain risk perceptions. Accordingly, the attitudes of farmers towards the risks and benefits of GM technology are considered in more depth in the next chapter.

Chapter 7: Q methodology study with Scottish farmers[9]

7.1 Introduction

Following on from chapter six, the aim of this chapter was to investigate farmer attitudes towards the risks and benefits of GM crops in Scotland. In order to achieve this aim, the objective of the work was to conduct a Q methodology study with Scottish farmers. The Q methodology study utilised the statements collected in the postal survey reported in chapter six. The purpose was to investigate farmers' perceptions of the risks and benefits of GM technology in agriculture, and thereby gain a deeper insight into the factors that might be related to their perceptions of the risks of GM crops, beyond the farm business and personal characteristics investigated in chapter six.

7.2 Background

Beyond what can be uncovered by questionnaire surveys and closed-ended questions such as those included in the study reported in chapter six, a more in-depth understanding of perceptions and attitudes can be informative, particularly when complex and contentious issues, such as the GM 'debate', are under consideration. Investigations into farmers' attitudes have revealed that there is a need to understand, not just the economic incentives of farmers as rational actors but other motivations (Guehlstorf, 2008).

As discussed in chapter six, there are a number of ex-post studies that have investigated measurable, structural characteristics relating to adoption of GM crops. A small number of studies have also asked farmers about their reasons for adopting the technology (Pilcher *et al*, 2002; Bennett *et al*, 2003; Yang *et al*, 2005; Gouse *et al*, 2003). Reasons identified as being important for adoption decisions include the aim of saving labour, the aim of reducing pesticide applications, the goal of obtaining higher yields and the goal of increasing profits.

While many studies have investigated consumer attitudes towards GM food and crops (see for example, Baker & Burnham, 2001; Gaskell *et al*, 2003; Grove-White *et al*, 1997), consideration of farmer attitudes is largely absent from the GM debate. Of the small

[9] Note that a version of this chapter has been published in Geoforum (http://www.sciencedirect.com.ezproxy.webfeat.lib.ed.ac.uk/science?_ob=MImg&_imagekey=B6V68-4PJ6BT9-1-1&_cdi=5808&_user=809099&_pii=S0016718507000954&_origin=browse&_zone=rslt_list_item&_coverDate=01%2F31%2F2008&_sk=999609998&wchp=dGLbVlW-zSkWb&md5=9fb2181ac59f7504a20d92650b4e020e&ie=/sdarticle.pdf)n)

number of studies that have enquired into farmer attitudes and perceptions relating to GM technology in agriculture, Cook and Fairweather (2003) concluded that attitudes and beliefs about the consequences of using GM technology were key factors affecting farmer decisions regarding use of GM in agriculture. Similarly, Illinois farmers who had adopted or planned to adopt GM crops were found to have more optimistic perceptions of GM crops, emphasising the importance of attitudes (Chimmiri *et al*, 2006). Chong (2005) found that Indian farmers' perceptions of Bt aubergine were focused primarily on the expectation of economic benefits.

The latter studies point to the need to investigate farmer attitudes to, and perceptions of, GM technology. When the aim is to conduct a more detailed exploration of attitudes, discourse analysis is a valid approach (Barry & Proops, 1999). Discourse is defined as all the conversations, comments, discussions and opinions that are held or made about a particular subject, event or issue. Q methodology is a form of discourse analysis and aims at an in-depth understanding of the attitudes of some members of a specific part of the population, but is not intended to lead to conclusions about the opinions of the population at large (Brown, 1993).

Originally used in the field of psychology and widely used in health studies, Q methodology is now used across a range of social science disciplines and studies, including political science, investigation of environmental issues and, to a limited extent, geography and sociology (see for example, discussion in Robbins & Krueger, 2000; Eden *et al*, 2005; Previte *et al*, 2007). The approach can be used wherever the aim is to investigate the attitudes and opinions that comprise the whole social discourse associated with a particular topic.

Q methodology has been used to explore attitudes towards a range of land use issues, including watershed management (Webler *et al*, 2003), sustainable forestry (Swedeen, 2006), location of waste facilities (Wolsink, 2004), the role of local knowledge of forest environments (Robbins, 2000), wolf management (Byrd, 2002), and forest management (Steelman & Maguire, 1999). Further, a number of Q methodology studies have been conducted with farmers (Walter, 1997; Brodt *et al*, 2006; Davies & Hodge, 2007) or have investigated wider agrarian issues (Levin *et al*, 2003; Peritore & Galve-Peritore, 1990). Wilkins *et al* (2001) specifically investigated the issue of GM crops. However, no previous studies could be found that had used Q methodology to investigate farmer attitudes to GM crops. Hence this research sought to fill this gap.

The remainder of this chapter is structured as follows: In the next section, the stages of Q methodology are described. This is followed by presentation of the results arising from this study, and the subsequent analysis. Finally, conclusions are presented relating to the findings about factors that have been shown to be connected to farmers' perceptions of risk associated with GM crops.

7.3 Method

Q methodology involves a number of stages, as follows. First, the researcher identifies the area of discourse and the relevant population. Having done so, the second stage involves the collection of statements (opinions) relating to the discourse. The third stage is the selection of a limited number of representative statements from all of those collected. Next, participants are required to rank or 'sort' the statements against a scale (usually agree to disagree). This is followed by the fifth stage of the process during which statistical analysis of the 'sorts' is carried out to enable the extraction of a few 'typical' sorts. Finally, these typical sorts are described and interpreted (Barry & Proops, 1999).

In the study reported here, the collection of statements (known as the concourse) was derived from open-ended questions included in the postal survey, as reported in chapter six. When conducting this first stage in Q methodology, it is important to ensure diversity of respondents, rather than large numbers or high response rates. As noted in chapter six, the stratification applied to the sample was the four agricultural census regions in Scotland. Because of topography, social history and population dispersion, these regions are core to the type and nature of farm business structure and farming activity. Thus it was considered that this stratification would provide the diversity of views towards the issue, necessary for the derivation of a satisfactory concourse. As noted in chapter six, responses by region differed slightly from being representative of the regions in percentage terms, but acceptable diversity was obtained. The only additional requirement was that farms included some aspects of arable production. As judged by the variables included in the survey, table 6.1 confirms considerable diversity of respondents.

Having collated the opinion statements, it was possible to structure the concourse under a number of thematic elements, as follows:

- Co-existence of GM and non-GM crops (160 statements)
- Overall view of GM (137 statements)
- Consumer opinion / customer demand / the market (124 statements)

- Environment / wildlife (93 statements)
- Crop management (89 statements)
- Costs / finances (62 statements)
- Information / safety (43 statements)
- Technology (28 statements)

From the full set of over 700 statements, 48 were selected to be representative of all views expressed by farmers. There were a number of steps involved in the selection process. First, there was a process of eliminating some of the statements, as follows. Repetitive or similar statements, statements that were too personal to be relevant to other farmers, statements that were factual and not opinions, and those whose meaning was unclear or not relevant, were eliminated. This process resulted in a reduced number of statements, and each of those remaining were then assigned to the relevant box in a matrix. This matrix featured, on one axis, the thematic elements as above, and on the other axis, the position represented by the statement (GM positive, GM negative, neutral). For example, under the thematic element 'Costs / finances' one of the 'GM positive' statements is: "*I would choose to grow GM crops if there was a bigger margin for growing them*". The next stage was to calculate the necessary number of statements to be retained in order to ensure that the final collection of 48 statements was representative of the number in each thematic element. To ensure a balance of views, the columns are equally represented. The final collection of 48 statements is known as the Q set (see appendix eight for the statements in the matrix). As with sampling people in survey research, the main goal in selecting a Q set is to provide a miniature that is representative of the larger population (of statements) being analysed (Brown, 1993).

The next stage of the research involved face to face interviews with participants during summer 2005 and spring 2006. These interviews were conducted with an appropriately diverse group of farm businesses, including, relatively small family farms, for example in a remote area of Fife and in Aberdeenshire, a mixed lowland farm near Elgin, a highly industrialised farm business near the coast near St Andrews, an urban fringe farm to the west of Glasgow, two large arable enterprises in the highly productive area of East Lothian, and others. During the interviews farmers were required to rank (or 'sort') the 48 statements comprising the Q set. These statements had to be arranged on a template, against a standard likert scale. The template of 48 boxes (one for each statement) formed the shape of a quasi-normal distribution and the seven point likert scale ran from 'strongly disagree' to ‘strongly agree’. The Q study sorting scheme is shown in table 7.1. The forced distribution used in Q methodology requires participants to place only a limited number of the statements at the extremes of the scale. In this way, they must consider which statements they feel most strongly about. In addition, as they work through the sorting exercise, participants compare every statement with every other statement and thus reveal the relative strength with which certain statements are viewed. Hence, what is demonstrated is not just their response to particular statements, but their overall attitude to the topic under consideration.

Table 7.1: Q study sorting scheme

Statement rank	-3	-2	-1	0	+1	+2	+3
Point on scale	Strongly disagree	Disagree	Somewhat disagree	Neutral / No opinion	Somewhat agree	Agree	Strongly agree
Number of statements	4	6	8	12	8	6	4

The next stage of Q methodology is the analysis of the ‘sorts’ using a software package designed for the process, in this case PQMethod (Schmolck, 2002). The first stage of the analysis involves correlating every sort with every other sort. Sorts are then factor analysed and rotated in order to reduce the data to a limited number of defining sorts, usually three or four, and no more than eight. The defining sorts that emerge from factor analysis represent different attitude groups that exist within the overall discourse relating to the topic under investigation. It is then the task of the researcher to interpret and describe the attitude groups.

7.4 Results

7.4.1 Responses to open-ended questions

As noted in chapter six, in the postal survey farmers were invited to respond in their own words to 13 mainly open-ended questions. Responses revealed that farmers have a good understanding and awareness of the potential risks and benefits of GM crops, and the issues involved in the debate. In order to provide initial insight into farmer opinions, consideration is given here to some of the responses received to some of the 13 questions.

Farmers were asked “*Do you think the introduction of GM crops into Scottish agriculture would be good or bad for Scottish farming*?”[10]. In response to this, 30% said

[10] Although this is not an open-ended question, farmers were asked to give reasons for their answer

‘good’ and 36% said ‘bad’. The remaining 34% either said they ‘don’t know’ or they said both ‘good’ and ‘bad’, depending on a range of circumstances, such as public opinion, the type of modification introduced, and whether or not it was proven safe. The reasons given for saying that the introduction of GM would be ‘good’ were generally based on the expectation that production costs would be lower and/or yields higher. Reasons given for saying that the introduction of GM crops would be ‘bad’ were commonly that it would be damaging to Scottish farming because the public does not want it. There were also some concerns about possible environmental impact.

When asked “*what do you think will be the main problems (if any) presented by the introduction of GM crops in Scotland*?” farmers referred to public distrust, the potential for cross-contamination of non-GM crops by GM crops, and the possibility of the development of so-called ‘superweeds’ that would be difficult to get rid of. The expectation was that these problems would be experienced first and foremost by the farmers themselves, although some respondents felt that consumers would also experience problems arising from GM. In a small number of cases the response was that ‘everyone’ or ‘the whole food chain’ would experience problems arising from the introduction of GM. Farmers were also asked what they thought the main advantages would be, and responded that these would likely be lower production costs, less chemical use and higher yields. Beneficiaries were expected to be the supermarkets, but also growers and plant breeders, and in some cases, consumers, through cheaper food.

An issue that frequently arises in public debates or surveys about GM crops is the potential impact on the environment, including farmland wildlife and biodiversity. For example, 91% of people who completed questionnaires as part of the UK-wide ‘GMNation’ debate agreed with the statement: “*I am concerned about the potential negative impact of GM crops on the environment*” (Heller, 2003). However, when the farmers were asked “*How do you think GM crops might impact on farmland wildlife (if at all)?*” responses included “no impacts”, “don’t know”, “cannot foresee any”, “wildlife is adaptable” and “will benefit wildlife if less chemicals are used”. Overall, 37% of farmers commented that they did not think there would be any significant impact on wildlife, or indeed that the impact would be beneficial. Forty five percent of respondents stated that they did not know how GM might impact on wildlife or they said that it could be good or bad, and only 18% were sure that the impact would be bad. Apparently the farmers in this survey do not share the same level of concern as the general public, about the potential impacts of GM crops on the environment and biodiversity. So only 18% of farmers' perceptions of GM technology were influenced by this particular aspect of environmental attitude, that is attitude towards wildlife.

While these responses reveal something about farmer attitudes, the use of Q methodology provides the opportunity to conduct a more structured analysis of attitudes. This is reported in the next section.

7.4.2 Results from Q sorting

As noted above, a sample of 48 statements was selected from those collected from the postal survey using a sampling matrix. These 48 statements were then printed onto individual cards and presented to 15 farmers during farm interviews, for ranking against a likert scale. The ranked statements formed each farmer's Q sort. The Q sorts collected during the farm visits formed the basic unit of data for analysis. The initial stage of the analysis was the construction of a correlation matrix of all the sorts. This is useful as it provides an indication of patterns of similarity between sorts. The Q sorts were then factor analysed, using Principal Components Analysis (PCA) of an inverted factor matrix. In this process the correlation matrix was examined to determine how many different families or groups (factors) existed. Hence the purpose of factor analysis was to determine if there was a smaller number of Q sorts that constituted patterns of discourse among the participants. Q sorts that were highly correlated with one another could be said to have a 'family' resemblance, and those belonging to one group were highly correlated with one another but uncorrelated with the sorts in other groups (Brown, 1993).

After conducting PCA, initial 'factor loadings' were derived for each of the Q sorts. The loadings showed the extent to which each Q sort was associated with each factor. The original set of eight factors (the default setting in PQMethod) was of interest only to the extent that it provided the basis for investigating the factors further. The next stage of Q methodology is to rotate factors (using varimax rotation) to "find the simplest structure in the data that can explain the greatest amount of variability" (Swedeen, 2006). Selection of factors for rotation in Q methodology can be based on a number of different approaches. The most commonly recommended approach is to use the so-called 'eigenvalue criterion', whereby those unrotated factors with an eigenvalue greater than one, are retained for rotation. In this study, this was not an appropriate option, since there were five factors with an eigenvalue greater than one, and the five factor solution was not satisfactory from an explanatory perspective. Thus a different approach was used, that of the ‘scree test’. In this test all the eigenvalues of the unrotated factors are plotted in a line graph, and factors retained for rotation only to the point of the ‘elbow’ in the line (figure 7.1). In this study, this selection approach yielded three factors. This was a satisfactory approach because the three factor solution was the one that provided the most coherent explanation of the sorts. Hence the study reveals three factor groups. Eigenvalues and percentage variance explained by each factor are as shown in table 7.2.

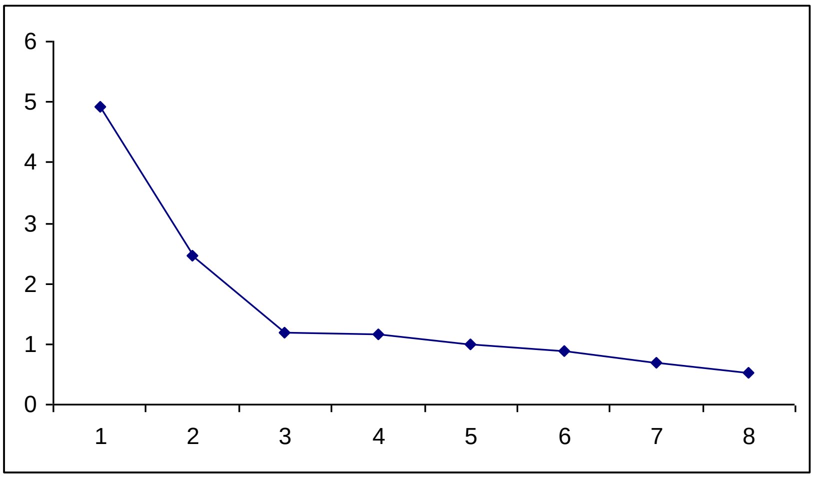

Figure 7.1: Scree plot of the eigenvalues of the unrotated factors

Table 7.2: Eigenvalues and variance explained

	FACTOR 1	FACTOR 2	FACTOR 3
Eigenvalues	4.9289	2.4491	1.1901
% expl.Var.	33	16	8

To interpret these three factors, factor scores were used. A factor score is the score for a statement that is an average of the scores given to that statement by all of the Q sorts associated with the factor. Hence factor scores were derived by taking the factor loadings of the sorts and weighting them to account for the fact that some were closer approximations of the factor than others. The weights were elicited by dividing each factor loading by 1 minus the square of the factor loading. The sort with the highest factor loading (in the case of factor one this is the sort labelled ‘Cluny’), was given the most weight $(0.75/(1-0.75^2))= 1.70$. Weighted scores were calculated in PQMethod for all 48 statements, based on how each sort associated with the factor scored that statement in the original sorting procedure. For convenience, the weighted scores were returned to the original Q sort format, such that the four statements with the highest weighted composites were assigned +3, the next six highest assigned +2 and so on. For clarity of understanding, these are the scores used for explanation of the factor groups.

As noted above, analysis of the Q sorts revealed three factors, and the converted factor scores were then used to interpret how the statements were ranked both within and between factors. The factor scores identified which statements had some degree of common ranking across factors, and which ones had a high degree of disagreement between factors. Differences of two or more between factor scores can be considered significant (Brown, 1993). Using converted factor scores helped to identify which statements typify a particular factor. The 48 statements with their factor scores are shown in table 7.3. Figure 7.2 demonstrates distinguishing statements and consensus statements. Distinguishing statements are those statements that distinguish a factor from the other factors, because the factor score is statistically significantly different from the score given to that statement by the other factors. Consensus statements are those that do not distinguish between any pair of factors. Results are discussed below, using the distinguishing statements from each factor, for explanation.

Table 7.3: Factor Q-sort values for each statement

STATEMENT	FACTOR 1 SCORE	FACTOR 2 SCORE	FACTOR 3 SCORE
1 Problems arising from the introduction of GM crops would impact on farmers as they are perceived as being custodians of land and are easiest to target	1	2	1
2 I don't know how GM crops might impact on farmland wildlife but wildlife is pretty adaptable	0	-2	-2
3 Problems arising from the introduction of GM crops would impact on the environment, that in turn affects everyone and everything	-1	1	-2
4 If proven 'safe' the introduction of genetically modified crops into Scottish agriculture would be good for Scottish farming	3	0	-1
5 I don't believe there is any difference in quality / safety of eating either GM or non-GM so cross-contamination would not be a problem	1	-2	-2
6 I might be encouraged to grow GM crops by clearly demonstrated advantages and no long or short term risks to environment	3	1	3
7 It would be better if Scotland is seen to be GM free	-2	1	0
8 I can't say what factors might encourage me to grow GM crops – it will depend on the features produced by the GM and which crop it is	1	0	2
9 If a farm nearby decided to grow genetically modified crops I would not be happy as I would not want my soil contaminated with GM pollen. I should have the right to decide what happens on my land	-3	0	1
10 I would not choose to grow GM crops because crops grown in countries which are completely GM free may get higher prices due to consumer demand	-2	2	0
11 I would choose to grow GM crops because technology should be embraced	1	1	-2
12 The main problem that would arise from the introduction of genetically modified crops in Scotland would be that it would reinforce the existence of input-dependent industrial agriculture	-1	-1	-1
13 I cannot understand the argument about contamination of GM crops - cross pollination or contamination are emotive words and we have always accepted it	0	-2	-3
14 The only advantage I can see from introducing GM crops would be being able to produce a crop at a lower cost, but this, as with all crop marketing, will just force us to take a lower price	0	-1	-1
15 The introduction of GM crops in Scotland should benefit wildlife because there is the potential for less spray to be needed	1	-1	1
16 Personally I can see no reason for not having GM crops other than the problem of bad publicity	2	-1	-2
17 I am not sure whether the introduction of genetically modified crops into Scottish agriculture would be good or bad for Scottish farming but until the public is in favour of GM crops they are a non-starter	0	3	0
18 Problems arising from the introduction of GM crops would impact on farmers who will have fields of crops they cannot get rid of	-1	-1	-1
19 All growers would benefit if GM crops were introduced to Scotland	0	-2	-3
20 I would be discouraged from growing GM crops by the risk of having groups of objectors arriving on our farm	0	0	-1
21 We have already seen a reduction in wildlife species due to natural habitat loss – GM crops would exacerbate this problem	0	-2	-1
22 I would choose to grow GM crops if there was a bigger margin for growing them	1	-3	2
23 I would not choose to grow GM crops because the risks are unknown and future generations should not be put at risk	-3	2	0
24 I don't know who would benefit if GM crops were introduced in Scotland	-1	0	3
25 I might be encouraged to grow GM crops by the fact that the modified plants may be easier to treat for mildew and many of our common everyday problems	2	0	0
26 I don't know if I would choose to grow GM crops. It would depend on press coverage	-2	0	1
27 The existence of both genetically modified crops and non-genetically modified crops in Scotland would mean that the natural, good food	-1	2	0

image of Scotland would be jeopardised			
28 The introduction of genetically modified crops into Scottish agriculture would be good for Scottish farming in as much as it may reduce costs of growing them	2	-2	2
29 I don't believe there would be any problems arising from the existence of both genetically modified crops and non-genetically modified crops in Scotland	1	-3	-3
30 The existence of both GM & non-GM crops would lead to problems for the purity of non-GM product but this is only relevant if a market continues to exist for guaranteed non-GM produce and that may become doubtful	0	0	3
31 The existence of both genetically modified crops and non-genetically modified crops in Scotland would lead to cross pollination and this must not be allowed to happen	-2	0	0
32 I do not think contamination of non-GM crops by GM crops can be prevented and it would just have to be accepted	0	-3	1
33 In future we may be able to grow GM crops for specific purposes or in conditions other than their natural environments which could be an advantage	1	0	1
34 Don't introduce GM crops - we are an island, we may be able to trade worldwide on our GM-free status	-3	3	2
35 I might be encouraged to grow GM crops when every one else is and the profitability of the crop make it necessary to go with the tide	0	3	0
36 I don't think there is any need for genetically modified crops as we are struggling to get a decent price for what we grow	-3	1	0
37 Interference from activists to trial crops should be dealt with severely in the law courts as the activists are only hindering the interests of mankind	3	-2	-1
38 I might be encouraged to grow GM crops if there was demand from consumers	2	2	0
39 The introduction of genetically modified crops into Scottish agriculture would be good for Scottish farming provided the correct characteristics are introduced e.g. disease control	3	1	3
40 I think the introduction of genetically modified crops into Scottish agriculture would be bad for Scottish farming but only because the public perceive it as bad	0	3	0
41 I'm not sure if the introduction of GM crops is likely to be a problem but there may be a problem with the surrounding environment, i.e. insects, birds and wildlife	-1	2	-3
42 I don't know if I would choose to grow GM crops because I still need to be convinced it is safe and not just commercial	-2	1	2
43 Contamination of non-GM crops by GM crops should be dealt with by crop destruction	-2	0	-2
44 If only 'natural' genes are added to GM plants then it's ok but if it involves using genes from a different species then it's not ok	0	-1	1
45 There would be very few advantages to the farmer from the introduction of GM crops in Scotland but if a nitrogen fixing gene could be implanted in cereals, together with disease resistance then long term security of food supply with low oil-based inputs could be guaranteed	2	1	2
46 Farmers would benefit from lower costs and increased yields if GM crops were introduced in Scotland	2	-1	0
47 I don't think there is a place for both GM crops and non-GM crops – it will have to be either one or the other	-1	-3	-1
48 Introducing GM crops may mean more attractive-looking products like bright red smooth tomatoes, although this may put buyers off because they will look as if they are GM and not natural	-1	0	1

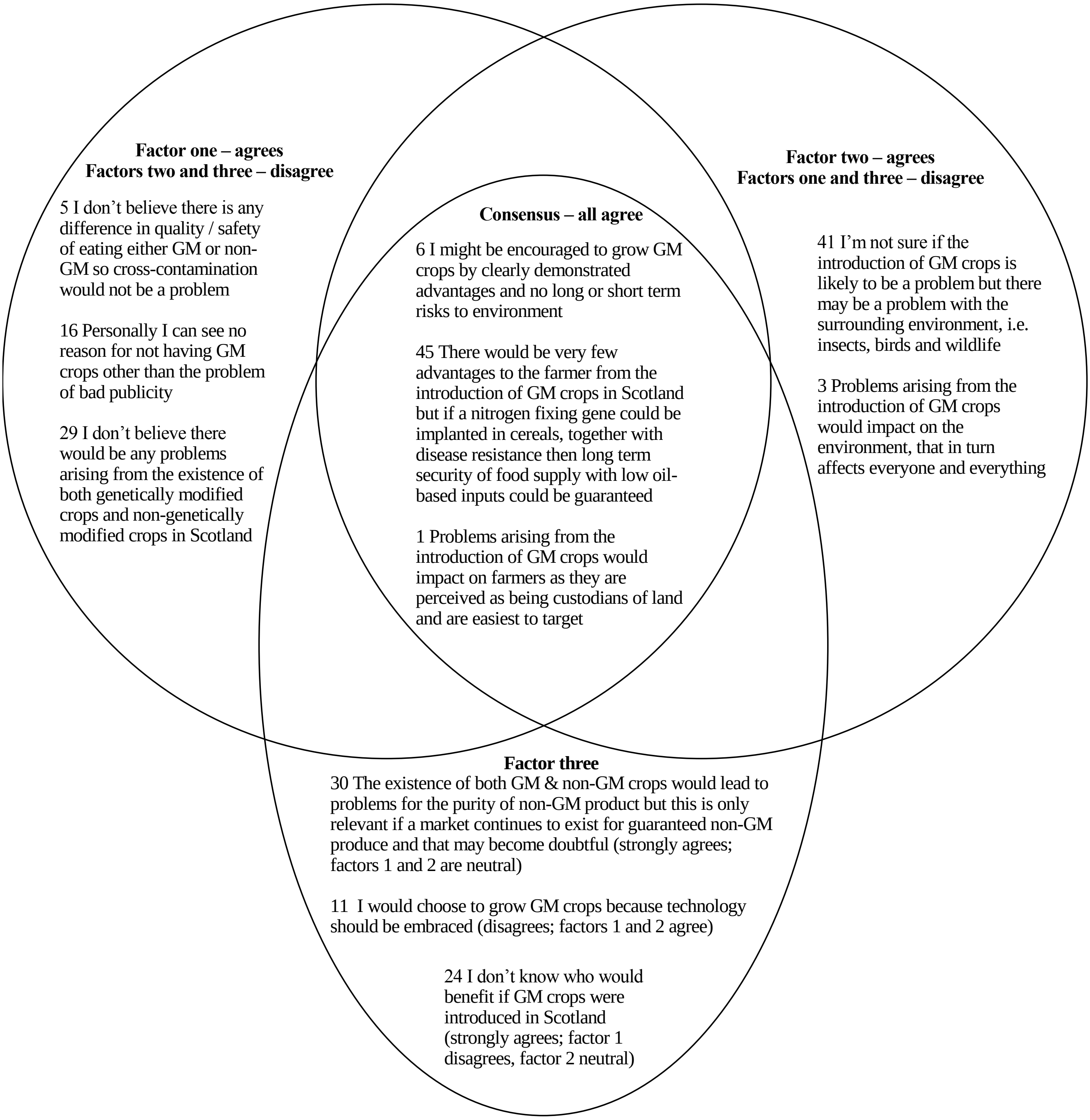

Figure 7.2: Disagreement and consensus between factors

7.5 Discussion of results

7.5.1 The concourse of statements

The statements collected from farmers in the postal survey suggested that a range of issues was impacting on their perception of risk associated with GM crops, including a number of those factors discussed in chapter three. Relevant issues included: Public opinion and the media; trust in regulators and biotechnology companies; opinions relating to wildlife and the environment; attitudes to technology development generally; uncertainty about impacts; distribution of impacts; and the extent to which they expected benefits to result from the use of the technology in agriculture. The Q methodology results enabled these responses to be analysed in a structured approach.

7.5.2 Factor 1 – Benefit believers

The results presented in table 7.3 and figure 7.2 suggest that factor 1 represents a position that is inclined to be positive towards the idea of GM. The factor does not appear to be adamantly pro-GM, but importantly is not as cautious towards the technology as factor 2 or as fatalistic as factor 3. This factor demonstrates some concern about safety, recognising that the technology needs to be proven to be safe (statement 4, converted factor score +3) but this does not mean that farmers in this factor are likely to be hesitant to adopt the technology because of safety fears (42, -2). Over and above considerations of safety, this factor sees the potential technological advantages of GM (46, +2; 25, +2). The position represented by factor 1 does not see any difference in the quality or safety of GM food compared to conventionally produced food (5, +1). In fact, this factor is not concerned about other farmers growing GM crops nearby (9, -3), the potential of cross-contamination (31, -2), or potential future risks (23, -3). Farmers in this factor are also likely to be unconcerned about the impact on wildlife (41, -1).

This factor could be said to describe optimists, those who tend to perceive risks to be small. Those represented by this factor believe farmers would benefit from lower costs and increased yields if GM technology was introduced into Scottish agriculture (46, +2) but do not expect it to be a magic formula for all farmers (19, 0). It is likely that those in this factor are generally more inclined to be technology-adopters, and whilst recognising that safety may be an issue with new technologies, are far more inclined to believe that the potential benefits are likely to outweigh any potential risks. It is likely that this position would refer to any new technology, suggesting that, to factor 1, GM technology is little different to any other agricultural technological development. In line with their largely pro-technology stance, farmers represented by this factor believe that protesters should be dealt with by the courts (37, +3), presumably as they are hindering technology development. Neither do they see any purpose in remaining GM-free as an island, as they think this is unlikely to provide any competitive advantage (10, -2; 34, -3). Indeed, discussions during farm interviews revealed that some farmers believe that the longer this country remains GM-free the greater the likelihood that the UK will find itself in a competitively disadvantaged position. Overall, farmers represented by factor 1 appear to believe that the potential benefits of the technology are likely to outweigh the potential risks.

7.5.3 Factor 2 – Risk perceivers

The position represented by this factor is much less inclined than factor 1 to be supportive of GM but is not necessarily anti-GM (6, +1). Factor 2 is certainly concerned about the potential risks (23, +2; 41, +2; 3, +1), and is much less sure of the possible benefits than factor 1 (19, -2; 46, -1). Importantly, unlike factor 1, this factor sees that being GM-free could be an advantage (10, +2). The position represented by this factor also shows recognition of, and concern about, public reaction and consumer demand (17, +3; 40, +3). Overall, the position represented by factor 2 is one that demonstrates much more concern about the potential risks than factor 1, and is also less convinced that GM will inevitably play a role in the future of farming in Scotland. Farmers in this group are likely to be reluctant adopters (if at all) (35, +3), and would probably be more willing to consider other options, such as GM-free, recognising that consumers may prefer this, and be willing to pay for it (10, +2). Overall, factor 2 farmers reveal themselves to be more concerned about the potential risks of GM technology in agriculture.

7.5.4 Factor 3 – Fatalists

Factor 3 results describe a somewhat fatalistic attitude towards GM technology and the problems that it might create (32, +1). They demonstrate uncertainty about who might benefit (24, +3), and about what might lead them to adopt the technology (8, +2). They are somewhat cynical about the idea of a lasting market for GM-free produce, assuming that the public will eventually accept it (30, +3). They appear to be unconcerned about the idea of protesters arriving on their farm should they grow GM crops (20, -1). They also appear to be unconcerned about the possibility of risk to wildlife (41, -3). However, they do not believe that all farmers would benefit (19, -3), and are unlikely to go ahead and adopt GM simply in the name of technology development (11, -2). Overall, this group appears to hold a somewhat cynical view of the world, not demonstrating a particularly strong viewpoint either in favour of, or against GM, and suggesting a position that believes ‘what will be, will be’. While their awareness of the potential risks and benefits is high, their position overall seems to be defined by a sense that they have little control over the technology and its possible introduction. This does not, however, lead them to view the technology as exceptionally risky.

7.5.5 Validation

In order to validate the interpretation and description of the factor groups, a number of the farmers were contacted again, after analysis of the results. Farmers were asked to read through the description of the factor group to which they had been assigned, and indicate whether they agreed that the attitudes expressed largely reflected their own position. In all cases they were happy that the description was accurate.

7.5.6 Consensus statements

Although the factors clearly represent different positions, there are a number of points of consensus between them (figure 7.2). The consensus statements represent the pragmatic farming viewpoint that they all share. Hence, they all agree that the technology is acceptable as another technological development if it is shown to be beneficial and without risk to the environment (statement 6; converted factor scores 3, 1, 3). Also, they all foresee that the farmer would be impacted by, and blamed for, any problems that arose (1; 1, 2, 1). Further, they agree that genetic modification may offer a solution to common agricultural challenges (i.e. nitrogen fixation) (45; 2, 1, 2). None of them agree that GM technology would reinforce ‘input-dependent industrial agriculture’ (12, all –1), and also, they all disagree that farmers might end up with fields of crops that they cannot sell (18, all –1). All of these consensus statements appear to be grounded in practical farming experience, and it is this common experience that binds together the farmers represented by the different factors. They all operate in the same ‘real-world’.

Overall, in line with many responses to the questions in the postal survey, and comments made during interviews, all factors demonstrate a circumspect approach to the possibility of introducing GM crops. None of the factor groups demonstrate a clear commitment to being either pro-GM or anti-GM, opting instead for a much more pragmatic stance. They are differentiated by the degree of caution and concern about potential risks, and the expectation of potential benefits. Factor 1 describes a discourse that perceives less risks, and that is more pro-technology, and more sure of the benefits likely to be realised through GM technology. Factor 2 describes a discourse that is less certain of the potential benefits and more open to other possibilities for the future of farming. Factor 3 suggests a position that is largely fatalistic, certainly not ignorant of potential risks and benefits, but not leaning in any particular direction.

7.6 Conclusions

The study reported in this chapter has revealed how a range of factors is related to farmer attitudes towards GM technology and their perceptions of risk. First, the over-riding message that emerged from this work was that the relationship between risks and benefits is crucial, since it is the balance of these two issues that determines, and will continue to determine, the acceptability of the technology to the farmers. This is the issue that the three factor groups demonstrate most clearly, since it is the extent to which they consider potential benefits are likely to arise that influences their perceptions of risk, and *vice versa*.

The second key issue that arose repeatedly in different aspects of the study, related to the opinions and position of others. Hence issues such as public opinion and consumer demand, and the position of actors such as the media, protesters, neighbouring farmers, NGOs, and supermarkets were extremely important to farmers' attitudes, and the likelihood that they would embrace the technology. Their own perceptions of the risks of GM crops were inextricably linked to the attitudes of these other groups. Kondoh and Jussaume (2006) found evidence of a similar recognition by farmers of their own position within a wider system of actors, whose views were important to the decisions made by the farmers about new technology adoption.

There is another issue that it is claimed is important in influencing peoples' perceptions of risk and which this study revealed: The issue of trust. Many comments from the farmers related to scepticism about the role of the seed companies, the cost savings to be made and who these would accrue to, the ability of regulators to monitor GM crops following release, and the ability of scientists to understand the potential impacts of the technology. All of these comments revealed a lack of trust in those with some degree of control and influence over the future of GM technology.

Farmers' risk perceptions were also influenced by their expectations about the distribution (equity) of impacts between different actors. Factor 1 was the only one expecting that farmers would benefit from the technology (through lower costs and increased yields) and, as discussed, this was the group with the least concern about potential risks.

A key finding revealed by this study is that farmers' views of GM technology in agriculture are underlain by uncertainty – a factor discussed in chapter three as being associated with risk perceptions. Farmers considered there to be so many 'unknowns' relating to GM crop technology that it is inevitable that many of them perceived there to be a high level of risk.

Overall, the findings from this chapter add an important layer of in-depth information and understanding to the findings reported in chapter six, and between them the chapters demonstrate the complexity of the issue of farmers' perceptions of risk relating to GM crops. The next chapter of this thesis draws together the findings from the four preceding chapters to present some overall discussion and conclusions about factors influencing risk perceptions.

Chapter 8: Discussion

8.1 Introduction

The first aim of this chapter is to summarise conclusions from the individual parts of the research (chapters four to seven), emphasising the factors that were found to influence risk perceptions. In presenting this synopsis of findings, the discussion integrates the issues and literature reviewed in chapter three. Following this, implications are presented, both in terms of what the findings may mean for acceptance and uptake of GM technology, and in terms of what the findings may mean for policy and decision makers.

8.2 Key findings

8.2.1 Meta-analysis

Results from the meta-analyses revealed that the amount that people are willing to pay for GM-free food (in other words, to keep consuming conventional food and avoid the GM equivalent), is substantially above existing food prices, and is considerably greater than the amount they are willing to pay for GM food presented as having benefits. People are also willing to buy GM food even when it is not presented as having benefits, but only at a price reduction. Further, the value of 'benefit' is far less than the other two values, both of which can be said to represent the value of risk perceptions associated with GM food. Overall, the value of risk that consumers perceive GM food to present, lies between 27% and 81% of conventional product prices. This claim is valid if it is accepted that the values, by implication, represent the value of risk that people perceive GM food to present. This is a reasonable assumption given the widespread acknowledgement that peoples' attitudes towards GM food are strongly influenced by perceptions of risk, and the recognition that the utility function embraces risk attitudes (Statistical and Applied Mathematical Sciences Institute, 2007).

Variables from two groups, cultural factors and question format factors, were found, in some cases, to influence the contingent values associated with GM food. These included two cultural factors - country of study and participant group – and two question format factors - elicitation technique and distribution method.

8.2.2 Campaigner survey

The results from the campaigner survey revealed evidence of an inverse relationship between perceived risks and benefits of GM technology. This supports the hypothesis, proposed, for example, by Alhakami and Slovic (1994), that risk perceptions are influenced by associated benefits. Given that this risk benefit relationship was shown, it is of interest to consider some of the issues found to be related to the value of benefits. Results revealed that respondents expected future benefits of the technology to be lower than benefits currently available. This is important as there has been considerable literature stating that the so-called 'first generation' of GM crops is objectionable to some consumers because it fails to offer benefits to them (the consumers) (see for example, Han & Harrison, 2006; Moschini & Lapan, 2006). The expectation is that future developments will offer consumer benefits (see table 5.1 in chapter five) and thus risk perceptions will diminish and the technology become more acceptable. Results here cast doubt on this assumption.

Importantly, the lack of expectation of future benefits expressed by the participants in this study suggests that they do not trust those making the claims about future benefits. Although this does not explicitly link perceptions of risk to issues of trust, there is an implied relationship.

Environmental attitudes were shown to affect the extent of risk perceptions, hence respondents who were more ecocentric believed that the technology presented greater risks. Another important issue revealed by the campaigner survey was that respondents expressed a strong degree of assuredness about the environmental impacts of the technology, which are strongly expected to be negative. Again this implies a lack of trust, this time in those supplying messages about the environmental benefits of the technology. Given the nature of the participants their views about the importance of the environmental impacts is not surprising. It is likely that because of their ecocentric view of the world their initial reaction to the new technology was one of scepticism and alarm. Their continuing objections to the technology demonstrate the importance of initial impressions in influencing levels of risk perception (Slovic, 2000).

Although demonstrating a high level of certainty about the potential environmental impacts of the technology, the respondents demonstrated a large degree of uncertainty about the potential health impacts. For example, 42% stated that they were unsure how much of a health risk there is to UK consumers from eating products containing GM ingredients. This underlines the importance of uncertainty in influencing risk perception.

The psychometric paradigm dimensions of risk that are shown to be important in the campaigner survey include the equity or distribution of risks and benefits. The fact that benefits are believed to accrue to biotechnology companies and some farmers, but not to consumers, is often cited as a reason why there has been resistance to GM crops in some countries (for example, Gaskell *et al*, 2000). Results to questions addressing this issue in the campaigner survey suggest that respondents believe the benefits do indeed accrue to large corporations and some farmers, but not to consumers (either here or in developing countries), or to farmers in developing countries. This then could partially explain why this group of potential consumers remain opposed to the technology. Clearly, this does not explicitly address the equity of distribution of risks, since it relates to benefits, but it does suggest strong concerns about the equity of impacts of the technology that can be expected to influence perceptions of risk, because of the connection between perceived risks and benefits.

More familiarity with the technology, for example through being in close proximity to an FSE trial site, apparently decreased perceptions of benefit of GM food. This is interesting, as the theory suggests that greater familiarity with a particular risky activity or product is likely to reduce the level of risk perception (Slovic, 2000). Again, given the inverse relationship between perceived risk and benefit, results here suggest the opposite is the case.

Overall, the campaigner survey largely supports the theory of the psychometric paradigm and the factors that influence levels of risk perception. The exception is the level of familiarity with the technology, where the opposite effect is revealed.

Several socio-demographic and cultural factors were shown to be connected to risk (and benefit) perceptions in the campaigner survey, notably gender, education, location (whether it was rural or urban), and, as already described, proximity to GM crop trial sites. There is evidence that, in some cases, women, those with lower educational qualifications, and those living in rural areas consider the risks of GM technology to be greater, and the benefits less, than men, those with the highest educational qualifications, and people living in urban areas. These findings confirm the importance of socio-demographic and cultural variables, as discussed in sections 3.3.1 and 3.3.2. Finally, it is worth mentioning that the statistical analysis suggested that there may be some weakly significant interaction between gender and NEP group, which would imply that, on their own, these two factors are not important in influencing perceptions of risk. However, the results were not conclusive.

8.2.3 Farmer postal survey

The survey with farmers revealed that a majority perceive GM crops to present a medium level of risk, slightly more than a third perceive there to be a high level of risk, and just over a tenth perceive a low level of risk. This demonstrates a high degree of caution amongst the farmers in the study, towards GM crops in Scotland. This caution appears to be strongly linked to uncertainty as the majority stated that they did not know whether they would adopt GM crops, and reasons given included statements such as:

> "*I don't know because of the lack of information*",
> "*I will wait and see what happens*",
> "*I need to see results from more trials*",
> "*It depends on public opinion*",
> "*I would rather wait for other farmers to try it first*", and
> "*I need to be convinced it's safe*".

This is important because, as discussed in chapter three, uncertainty is thought to be important to perceptions of risk. Uncertainty is clearly demonstrated here.

Results from the postal survey sent to farmers revealed that a range of factors influence farmers' perceived level of risk associated with GM technology, and their potential adoption decisions relating to GM crops. Results show that in this study it is the farm business characteristics, rather than the personal characteristics of the farmers, that are more significant to the level of perceived risk. Thus, farmers with the lowest level of perceived risk associated with GM crops (and thus more likely to adopt) are less likely to be solely a farm owner or solely a farm tenant, less likely to grow barley as a main crop, more likely to grow other, unspecified types of cereal crops, or potatoes, and, unsurprisingly, are more likely to think that GM will be good for Scottish agriculture. They are also more likely to be female although gender results should be treated with caution because only 4% of respondents were female. The 'other types of cereal crops' results should also be treated with caution for the same reason. No interactions were found between pairs of variables. Including 'think GM will be good' as a co-variate in an ANCOVA model confirmed the importance of the 'grow barley as a main crop', 'grow potatoes as a main crop' and 'ownership status' variables in influencing the risk perception values.

8.2.4 Q methodology study

The Q methodology study with farmers revealed how a range of factors is related to farmer attitudes towards GM technology and their perceptions of risk. First, the over-riding message that emerged from this work was that the relationship between risks and benefits is crucial, since it is the balance of these two issues that determines, and will continue to determine, the acceptability of the technology to the farmers. This is the issue that the three factor groups demonstrate most clearly, since it is the extent to which they consider potential benefits are likely to arise, that influences their perceptions of risk.

The second key issue that arose repeatedly in different aspects of the Q methodology study (the statements collected via the postal survey, the farm interviews and the Q sorting exercise) related to the opinions and position of other stakeholders. Hence issues such as public opinion and consumer demand, and the stance taken by other actors such as the media, protesters, neighbouring farmers, NGOs, and supermarkets, were extremely important to farmers' attitudes, and the likelihood that they would embrace the technology. Their own perceptions of the risks of GM crops were inextricably linked to the attitudes of these other groups.

Trust is another issue that is claimed to be important in influencing peoples' perceptions of risk, and that the Q methodology study revealed to be important. Many comments from the farmers related to scepticism about the role of the seed companies, the cost savings to be made and to whom these would accrue, the ability of regulators to monitor GM crops following release, and the ability of scientists to understand the potential impacts of the technology. All of these comments revealed a lack of trust in those with some degree of control over GM technology.

Farmers' risk perceptions were also influenced by their expectations of the distribution (equity) of impacts between different actors. The only group of farmers expecting that farmers could benefit from the technology (through lower costs and increased yields) was the group with the least concern about potential risks. Further, all three farmer groups identified, agreed that it was likely to be farmers (themselves) who would be negatively impacted by the technology because they would be blamed if something went wrong. As reported in chapter three the distribution of impacts is one of the psychometric paradigms of risk thought to influence levels of risk perception. The Q methodology study supports this.

A key finding of the Q methodology study is that farmers' views of GM technology in agriculture are underlain by uncertainty – a factor discussed in chapter three as being associated with risk perceptions. This aspect of the results has already been referred to in section 8.2.3 with regard to the postal survey conducted with farmers. This was confirmed by the Q methodology study. Farmers considered there to be so many 'unknowns' relating to GM crop technology that it is inevitable that many of them perceive a high level of risk.

8.3 Implications of the research

In this section consideration is given to the implications of the research.

8.3.1 Different social and cultural groups will respond differently

This research found that a number of socio-demographic factors are important in terms of the factors impacting on perceptions of risk relating to GM food and crops. The implication here is that if suppliers of GM foods wish to instigate targeted promotional campaigns, there may be certain groups more amenable to such marketing messages than others. Given that much consumer marketing research aims at identifying consumer segments, this is pertinent information. Interestingly, in the farmer study there was some suggestion that men have a higher perceived risk of the technology than women, suggesting perhaps that this minority farming population might be among the pioneers in terms of adoption.

A number of cultural factors were found to be important in impacting on perceptions of risk relating to GM food and crops. Specifically, these are the residential or farming location, the country of study and the participant group. Again, there are some clear messages about consumer segments that could be successfully targeted by promotional campaigns.

Findings about country of study confirm the widely acknowledged position that those in the USA are more likely to accept the technology than those in other countries (Herrick, 2005). This variation between countries has implications. One implication for policy-makers is that globally harmonised regulations, such as the Cartagena Protocol on Biosafety, may not be appropriate where they ignore national differences in consumer concerns and preferences.

In terms of participant group, the group ‘shoppers’ expressed a greater WTA value, than the general population. This suggests that if GM foods were to be priced at a level based on hypothetical values obtained from WTA studies with the general population (i.e. when they are not actively shopping), this might not be enough of a reduction to induce people to buy, when they are actively shopping (i.e. when they are ‘shoppers’). It appears that when shoppers are confronted with the product in-store, they require a greater reduction before they are willing to accept the GM alternative, than stated in the hypothetical studies conducted beyond the shop environment. The environmental economics literature critiquing valuation studies, usually assumes that hypothetical WTP values are larger than actual values. For example, MacMillan (2004) found that hypothetical bias exists and has an average calibration factor of 1:4 between real and hypothetical WTP values. Thus, while people might state that hypothetically they are willing to pay £4 extra for GM-free food, they might actually only be prepared to pay £1 extra. MacMillan (2004) suggests that different perceptions about uncertainty over the benefits provided, and unfamiliarity with the good being valued, may play a role in creating this hypothetical bias, both issues that could be relevant to the GM discussion. Thus, any pricing strategy based on hypothetical studies would need to consider this issue.

Although the purpose of hypothetical values elicited from valuation studies is frequently to provide decision-makers with an indication of the value of certain goods or services for which no economic values exist, questions have been raised about their usefulness. For example, MacMillan (2004) notes that "*although stated preference techniques are increasingly being applied to value environmental resources, concerns remain about the reliability of the benefit estimates generated. The resulting values can be controversial and difficult to verify, and stated preference approaches have been criticised by economists and non-economists alike*". Further, he states that there is a "*fundamental problem of asking hypothetical questions in an unfamiliar context*". The results presented in chapter four add to these discussions. The implication here is that the economic values derived from the meta-analyses would need to be utilised with caution, and are perhaps of greatest use for demonstrating the relative values placed on risk and benefit. Nevertheless, one reason for conducting meta-analysis is to enable elicitation of values that, because they are averaged across a range of studies, are more reliable than single studies.

Environmental values were found to impact on perceptions of risk relating to GM food and crops. In line with the myths of nature theory (Wickson, 2007), it is possible that respondents do not all view nature as the same. Thus while the most ecocentric may view nature as capricious, it is the case that those least ecocentric are more likely to view nature as either fragile or perhaps even robust within limits. This being the case, it may be that some 'campaigners', those least ecocentric, will be more likely to accept some types of GM food in the future. Correspondingly there are others who can be expected to remain more staunchly opposed to the technology.

A number of farm business characteristics were found to be important for farmers' perceptions of risk of GM crops. Qualitative results revealed that it may be harder to persuade urban fringe farmers to adopt the technology, precisely because of their proximity to population centres and their greater concerns about protesters. The implication is that it is possible that early adopters might be farmers who are located further away from populated areas. Thus companies promoting the technology might want either to focus on farms beyond the urban fringes, as these may be more open to adopting the technology, or to provide urban fringe farmers with extra incentives or assurances of security.

There is a number of implications that arise from the finding that enterprise type is related to perceived level of risk associated with GM crops. The significance of enterprise type is important because the GM crops approved for cultivation in the EU so far are of little use to Scottish farmers. Generally, approvals have been for maize which is little grown in Scotland. The implication here is that uptake of the technology may become more likely as and when new modified crops that are useful to Scottish agriculture are approved at EU level. For example, a number of the farmers mentioned that GM crops with a nitrogen fixing gene would be enormously useful. Hence if this were to be developed it might be the modification that would persuade Scottish farmers that the potential benefits on offer are so big as to outweigh any potential (perceived) risks. Nevertheless, it remains difficult to predict when the benefits presented by a modification of interest to Scottish farmers will outweigh the many concerns about the technology, expressed during the study. For example, the fact that those farmers cultivating barley perceive the greatest level of risk is hypothesised to be related, at least in part, to the image portrayed by the malt whisky industry. This is unlikely to change. Hence even if GM barley were to become commercially available (an important crop for Scottish farmers) reluctance to adopt because of the likely impact on the whisky industry and the image of Scottish farming, may be a lasting obstacle to cultivation. To counter this, it appears that potato growers may be less resistant to the technology. By implication, they may be among the early adopters.

Ownership status was found to be significantly related to perceptions of risk, such that those farmers who were both owners and tenants had the lowest level of perceived risk. This implies that, because business risk is diversified across the business structure, they may be more likely to adopt ahead of those farmers who are solely owners or solely tenants.

Overall, results indicate that different groups of people can be expected to react differently towards GM technology.

8.3.2 The influence of third parties is important

This research showed that the behaviour of other actors is important to perceptions of risk relating to GM food and crops. Specifically, the influence of other actors, or the likely reaction and behaviour of others, is important to farmers. This influence of others on farmers' decisions about new technologies is illustrated by work with a number of the farmers involved in the FSEs (Oreszczyn, 2006). Further, this aspect of the Q methodology results corroborates one part of the Theory of Planned Behaviour (TPB) (Ajzen, 1991) relating to subjective norms. It can be seen that in the case of the farmers they had a wide variety of other actors in mind and were concerned about how that particular group of actors (protesters, consumers, general public, neighbouring farmers, the media, organic farmers, supermarkets etc) might react if they chose to adopt GM crops. The fact that a number of the participating farmers considered the risks relating to consumer demand to be important is of relevance, as it has been shown that consumer concerns have had a significant impact on the 'GM debate' so far.

The implication of this for uptake of the technology is that farmers are unlikely to choose to adopt GM crops just because a modification and crop that is useful and relevant to their farm business is approved for cultivation. There is potentially a long chain of action and reaction amongst many different stakeholders and actors impacting on farmers' levels of risk perception, and hence willingness to adopt the technology.

Related to the issue of third parties, is the role of the media, cited by farmers as important in influencing the views of other groups. Farmers did not suggest that the media would directly impact on their own decisions or risk perceptions, but stressed that they were aware of the media influencing public opinion (negatively) and thereby indirectly impacting on their own adoption decisions. Thus farmers demonstrated an acknowledgement of the presence of the social amplification of risk via the media. By implication, media coverage is likely to be important in the chain of perceptions and behaviour that leads (or not) to farmers growing GM crops.

8.3.3 Impacts must be seen to be equitable

The equity of impacts expected to arise from the application of GM technology in food and crops, has been shown by this research to be important to perceptions of risk.

There have been claims that future modifications will help those in developing countries who are currently suffering food shortages, through the development of technologies such as drought-resistant crops (Pretty, 2001). This would, it is argued, result in a more equitable distribution of potential benefits, by helping those whose needs are greatest, rather than the majority of benefits accruing to the companies controlling the technology (as others argue has been the case). However, as has already been demonstrated, respondents to the campaigner survey were reluctant to believe the claims made about future benefits. The implication for acceptance of the technology is that current positions are likely to be slow to change without strong evidence of equitable distribution of benefits to those whose needs are perceived to be greatest. This would need to be balanced by a belief that the risks are likewise equitably distributed and do not impact excessively on those least able to cope with, for example, any negative environmental or health effects.

Many of the farmers expected that benefits would accrue to big businesses (seed companies, biotechnology companies, supermarkets), and that the negative impacts would fall on themselves, other farmers, organic farmers, the environment, and so on. The implication of this is that farmers will need to be convinced (like the campaigners) that the distribution of benefits is more equitable, and that the risks will not fall disproportionately on the farming community, before they are likely perceive the risks of GM crops to be low and therefore choose to adopt them.

8.3.4 If benefits are not perceived and believed, risk perceptions will persist

The relationship between perceived risks and benefits has been found to be important to perceptions of risk relating to GM food and crops.

Specifically, the results from the campaigner survey revealed evidence of an inverse relationship between perceived risks and benefits. The implication of this ought to be that if future modifications present features that are perceived by campaigners to be beneficial, perhaps to the environment or themselves, or those currently suffering food shortages, they may begin to perceive the technology as potentially less risky and thus be more accepting of it. However, as noted, campaigners demonstrated scepticism about the claims made about the future benefits of GM technologies, and indeed have already rejected any claims that certain existing GM crops are better for the environment. Hence the expectation that the promise of future benefits will lead to reduced risk perceptions looks to be unrealistic, or at best, optimistic.

It is interesting to note that this research shows that the risk-benefit relationship is important to levels of risk perceived by farmers. First generation GM crops (i.e. those that were first to be commercialised and that remain the most widely available for cultivation) are thought to be objectionable to some consumers because they offer benefits only to farmers and biotechnology companies. As Gaskell *et al* (2000) state, the 'achilles heel' of first generation GM crops, from the point of view of consumer acceptance, was a perceived lack of usefulness to them. Ford (2003) stresses that the first generation of GM crops was designed to make cultivation easier, and thus benefit farmers. However, the farmers in this study are apparently unconvinced that GM crops offer benefits to them, at least not that are sufficient to outweigh potential risks such as those posed by protesters, loss of business, the impact on the image of Scottish farming, and so on. Hence the implications are that providing agronomic benefits may not be adequate, since farmers are acutely aware of potential problems 'beyond the farm gate'. They believe that this is not just a business decision for themselves based on agronomy, but a wider social issue related to public perceptions, consumer demand, the position of the supermarkets, the media stance, the public image of agriculture, and so on. Thus, the concerns of these other actors will need to be addressed before there is likely to be widespread perception that benefits outweigh the risks, and before subsequent acceptance and adoption of the technology by farmers.

8.3.5 Social trust is central to the GM debate

Trust was found in this study to influence perceptions of risk. Specifically, the study with campaigners revealed a significant lack of trust in those making the claims about potential future benefits of GM technology, thereby indirectly influencing perceptions of risk, as demonstrated in figure 3.5. As respondents are sceptical about the claims of future benefits of GM technology, this suggests that the perception of high risks will remain, at least amongst this section of society. It can be hypothesised that opposition and protest are therefore likely to continue. As farmers also demonstrated considerable mistrust about a range of organisations with responsibility for regulating, managing, researching and developing the technology, they are also likely to continue to perceive that GM crops present a high degree of risk and therefore remain reluctant to grow them.

As these aspects of the work reported in this thesis have revealed a lack of trust in institutions and decision-makers, this implies a need for greater dialogue between bodies such as regulators, and growers and consumers. If the policy aim is to encourage GM technology, then policy makers need to address what may be a broader social issue related to trust and scepticism. The issue of trust ought to be something over which they (the policy makers) have some degree of influence, hence they need to put in place processes and procedures that enable people to feel more integrated into decision-making processes.

While improved stakeholder involvement in decision making is stressed as being important for addressing the issue of lack of trust, there are also doubts in the literature that there is such a direct connection. As Irwin (2006) states "enhanced engagement alone cannot be presented as an antedote for public scepticism over technical change". However, this is not to say that increased, and early consultation, should not occur. Indeed, perhaps the primary criticism of the GMNation? debate is that it occurred too late. The GM debate had already been framed by numerous years of campaigning by those opposed to and in support of the technology, and by the media focus. The GMNation? process was therefore viewed by some as token consultation and re-inforced the lack of trust, rather than helping to rebuild it.

Also, the extent to which trust can be re-instated (once lost) has been questioned. A report produced by the University of Sussex claims that as there is perceived to be greater uncertainty in the world, people have grown ever-more critical of political institutions (ESRC Global Environmental Change Programme, 2000). The implication of this (the authors claim) is that "*trust will never be restored absolutely and unconditionally, but has to be continually fostered and re-built*".

Nevertheless, as trust was shown here to be important to risk perceptions, it is an issue that needs to be addressed.

8.3.6 Perceptions of risk are strongly associated with uncertainty

This thesis has revealed that uncertainty is relevant to perceptions of risk relating to GM food and crops. In the campaigner study uncertainty was demonstrated about the potential health risks of GM foods. Likewise, farmers intimated that their reluctance to adopt GM crops was linked to a high level of uncertainty. As noted in chapter three, the issue of uncertainty can be broken down, and various types of uncertainty identified. For example, it has been proposed that technologies such as GM have led to the creation of new types of uncertainty, including ambiguity (the contradictions that are presented by opponents and proponents), ignorance (what is not known) and indeterminacy (the fundamental uncertainties surrounding the technology) (Wickson, 2007). It is likely that the uncertainty experienced by both the campaigners and farmers encompasses all three types.

Further, if the uncertainty scenario number two proposed by Powell *et al* (2007) "I don't know about GM food; that's okay because it isn't that important or relevant to me" were applicable in this case, then this study would have been less likely to find that uncertainty was related to perceptions of risk. It seems more likely that the uncertainty scenario number four is applicable "I don't know much about GM food and I want (or need) to know more, so I intend to learn more about it" or possibly, one "I don't know anything about GM food; I will leave it to experts to tell me what I need to know". These assume that the uncertainty experienced by people in relation to GM food is internal or personal uncertainty and makes them perceive the technology to be risky.

Demonstrating that uncertainty is an important factor impacting on perceptions of risk has a number of implications for acceptance of the technology. People are unlikely to adopt or accept the technology until such a time as the perceived uncertainty has been removed. This could occur if they have the opportunity to gain more knowledge or experience, either through personally investigating the issue or experiencing the food (or in the case of the farmers, through cultivating it) or waiting to be told more about it. By implication, as people become more certain about the technology and its potential impacts, they may be less likely to reject GM food and crops, as their perception of the risks decreases accordingly. So it might be expected that the longer the period of time that GM food is present in the food chain, the more acceptable it will become, even in those countries where it is currently not well received. However, as demonstrated in chapter five, the relationship between familiarity and acceptance is not always straightforward, and in some cases greater awareness, or familiarity, may in fact lead to greater likelihood of rejection. This suggests that one aspect of the psychometric paradigm theory of dimensions of risk is incorrect and that greater familiarity does not actually reduce perceptions of risk. While questioning this aspect of the psychometric paradigm, however, this finding supports MacKenzie's (1990) theory 'the certainty trough', in which he rejected the idea that more knowledge of a technology and greater familiarity with it, equals less uncertainty and thus greater acceptance.

There are further grounds for questioning the idea that greater knowledge reduces uncertainty and leads to greater acceptance. The claim that people need to be 'taught' about the technology, has been put forward by proponents, and can serve to alienate people by dismissing their own understanding and perspective of the issues, the implication being that they are largely ignorant and simply need to be educated about the 'facts'. For example, it was noted in an ESRC report that "*politicians have perceived hostile public reactions to GM foods to be mis-informed and emotive*" (ESRC Global Environmental Change Programme, 2000). As has already been shown, there any many more facets to uncertainty than potential lack of understanding, and this simplistic approach towards 'lay' knowledge is neither helpful nor constructive in overcoming the gulf between those opposed and those in support of the technology. The idea that the public need to educated about the facts so that they will then 'see sense' and make the right decisions, is not a new approach to the promotion of public understanding of science. The so-called 'knowledge deficit' model of public understanding is entrenched in many aspects of science and technology and is considered further below.

The knowledge deficit model assumes that public uncertainty relates to a state of "not knowing" (Powell *et al*, 2007) and that what is required is therefore education and provision of information. Under this model it is assumed that people do not behave in the 'correct' way because they do not understand. Therefore, the argument runs, if they are provided with the correct information and facts they will change their behaviour accordingly. The provision of "expert" information seldom addresses public concerns (Pidgeon *et al*, 2005), but the deficit model remains fairly pervasive amongst scientists, experts and decision-makers. This is despite widespread acknowledgement within the social sciences that people construct their risk perceptions by drawing on a wide range of social and cultural factors (Shaw, 2002) and frame risk issues not in a narrow technical sense but by including issues that are relevant to their lives (Horlick-Jones & Prades, 2009). As has been demonstrated throughout this thesis, both in relation to the review of earlier studies, and in terms of the research undertaken for the thesis, there are many reasons why people do not behave in the 'correct' way, and there is a range of factors related to peoples' perceptions of risks. As discussed in this section, uncertainty is a multi-faceted issue and has been shown by this research to be strongly connected to perceptions of risk. That being the case, and given that perceptions of risk are one of the key factors that have led to the GM debate being so polarised, it can be argued that the issue of uncertainty needs to be addressed if the debate is to be moved forward.

These results imply a need to investigate what the uncertainties are (for example, what is the nature of the ignorance, indeterminacy and ambiguity that farmers and campaigners believe exist?), and what is known that has not been effectively disseminated (thereby addressing ignorance and indeterminacy that need not exist), perhaps because trusted information sources have not been used. There is a need to acknowledge that there are uncertainties where they exist, and thereby acknowledge that there may be indeterminacy, and knowledge bias in information provided, and a need to push for clarification where this is desired, thereby minimising ambiguity. Ultimately, there is a need for more research into what is uncertain to people, the potential impacts and implications of the introduction of the technology into the food chain and into the environment, and an effective information dissemination programme to communicate findings. Further, peoples' involvement in deciding what are the important questions is key. All of these issues need to be tackled if the debate is to be moved forward.

8.3.7 Stakeholder involvement is needed to address issues of trust and uncertainty

The complex issues of trust and uncertainty have been shown by the results presented in this thesis to be related to perceptions of risk. As noted in the previous sections, stakeholder participation in risk negotiation is central to addressing issues of trust and uncertainty that underlie perceptions of risk, in moving away from the knowledge deficit model of the public understanding of science, and in acknowledging that social and cultural values shape perceptions of risk and as such need to be included in risk assessment procedures.

One of the earliest typologies of stakeholder involvement is Arnstein's (1969), ladder of participation (figure 8.1).

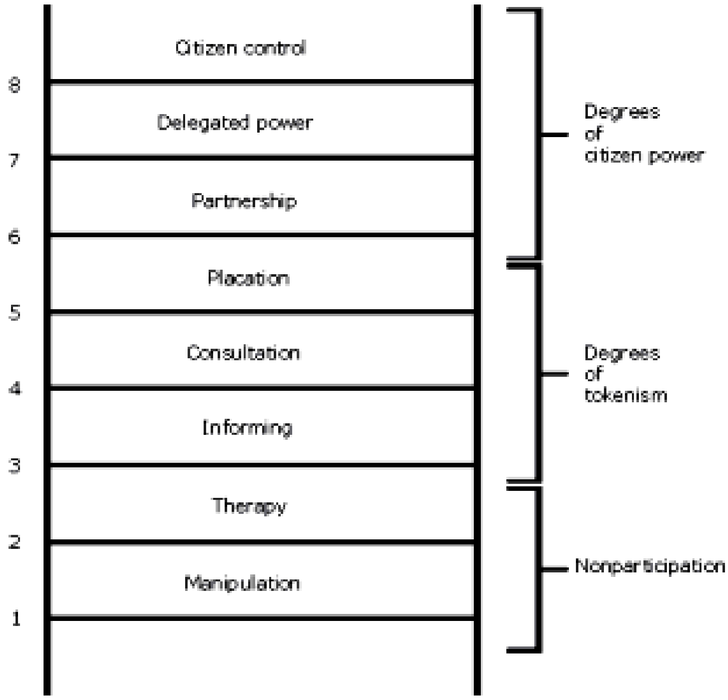

Figure 8.1 Ladder of participation

Each rung corresponds to the amount of power that stakeholders have in the decision process. The author suggests that it is not until rung (6) Partnership that stakeholders are able to negotiate and engage in trade-offs with those who traditionally hold the decision-making power. Arguably this is the position required in the GM debate, a position not reached by the GMNation? debate, which can be classified rather as rungs (3) Informing and (4) Consultation. At this level of participation, stakeholders may hear and be heard but lack any power to be sure that their views will be heeded or acted upon by those in power.

More recently, and more simply, participation has been defined as having three possible levels of involvement of stakeholders, namely, targeted information campaigns, consultation exercises such as questionnaires and focus groups, and activities that give stakeholders some decision-making power (Rowe & Frewer, 2000). Again, the GMNation? debate process only encompassed the first two stages of these alternatives.

Thus what is needed is a process of stakeholder involvement that occurs early enough in the process to enable stakeholders to have some degree of decision-making power. Indeed, one of the evaluation criteria deemed to be relevant for evaluating consultation processes is 'early involvement' (Rowe & Frewer, 2000). That is, stakeholders should be involved as soon as "value judgements become salient". In the case of the GMNation?

debate the legislative development process was all but complete in the EU so there could never have been any intention to use the results of the debate to contribute to the decision-making process relating to legislation design. However, one way in which wider stakeholder involvement in the GM decision-making process in the EU could be enabled is described below. This might serve to address some of the issues around trust.

8.3.8 Legislative changes are needed

Results obtained by this research revealed a sense of lack of control over exposure to the technology and little expectation that authorities will allow individuals greater control in the future. This is particularly important as the EU claim that their legislation is designed to ensure public safety and guarantee consumer choice. Results from this study suggest that campaigners have little sense of having a choice about exposure to GM food and crops. The results show that the regulations may not have achieved one of their stated aims – that of ensuring consumer choice.

There are two issues that are worth mentioning here about the current operation of EU legislation relating to GM crops and food. First, the European Commission are currently authorising GM approvals after the Council of Ministers and MEPs fail to reach a majority decision each time an application for approval of a GM crop or food item is placed before the EU institutions. The latter two groups are elected and this failure to reach a majority decision is likely to be related to their awareness of electorate resistance to the technology. All recent EU approvals have been passed by the Commission. This appears undemocratic since unelected officials make a decision that elected officials are not prepared to take. This does not encourage residents of the EU to feel they have any say in the decision-making process and thus fails to address the issue of a sense of lack of control over exposure to the technology that was revealed by this research to be linked to perceptions of risk. So one way in which wider stakeholder involvement in the GM decision-making process in the EU could be enabled is as follows. The approvals process, which occurs on a case by case basis, could be extended to provide the opportunity for wider stakeholder involvement and incorporation of non-scientific issues. This might help move the GM debate forward in a positive way.

Second, meat and other animal products produced from livestock fed with GM feed, do not currently have to be labelled as such, even though the animal feed has to be labelled as GM. Again, this does not give the consumer the choice if they wish to avoid eating meat from livestock fed with GM food. The importance of this issue to some consumers is demonstrated by table 2.4 (chapter two) outlining supermarket claims about animal derived products and their GM-feed status. In addition, a petition was submitted to the European

Commission in 2007 calling for such products to be labelled (Greenpeace, 2007). The implication for policy-makers is that if they wish to give consumers personal control over exposure to GM technology then there is a need to redesign the legislation. This might also help move the GM debate forward.

The recognition that there are many aspects to peoples' perceptions of risk implies there is a need for a different approach to formal risk management processes. The problem of traditional risk management has been clearly demonstrated by the legislative position on approvals within the EU. Since the agreed procedure is that member states must demonstrate scientific proof of harm to the environment or to human health in order to reject an approved crop, there is no allowance for consideration of wider social, cultural, psychological or political issues. Therefore, the risk management process needs to move away from a focus on the quantification of known and measurable risks (Wickson, 2007) towards risk decision making that accepts uncertainty as inherently related to peoples' understanding of risk and that accordingly seeks to negotiate with stakeholder groups.

8.4 Conclusions

The purpose of this chapter has been to draw together the findings from all parts of the thesis and discuss some of the implications of the results. The next and final chapter of the thesis briefly summarises the key points made here.

Chapter 9 Conclusions

9.1 Introduction

This chapter presents some suggestions for further areas of research and concludes with four key messages that arise from the research about how best to move the GM debate forward.

9.2 Recommendations for further research

Recommendations for potential areas of further research are presented, based in part on the identification of aspects of the thesis that could be improved, given more time and resources and with hindsight.

There are a number of specific methodological issues and areas for future research that could usefully be addressed, as follows:

- As revealed by the meta-analysis, research needs to be conducted on the impact of choice experiment format on WTP values. This might help to remove some of the difficulty with applying hypothetical values to real-life situations. If a consistency can be identified (e.g. choice experiments generally elicit hypothetical values that are 25% above actual values) the outcomes of such studies will likely be more useful.
- Based on the survey conducted with campaigners, it would be useful for the NEP scale to be revised so as to include statements relating to equitable distribution of resources and access to energy supplies, for example. This is a necessary updating of the scale, based on the current environmental discourse.
- It is recommended that more work be conducted with campaigners – those with the highest levels of perceived risk. This is particularly important as numbers in this study were limited and they represent an important group of people.
- It is recommended that more work be conducted with farmers as they represent an important group of people at the heart of the issue of GM technology.
- As GM technologies are not homogenous, work investigating both consumer and farmer attitudes towards different modifications and different crops and food items would be of value. The usefulness of this approach was hinted at already in the farmer study through mention of the need for nitrogen fixing crops, and the finding that crop type was linked to levels of risk perception – clearly there may be some crops and modifications of greater acceptability than others. So far the technology has generally been presented and discussed as having a single identity.

- There is a need to investigate in more depth the nature of the uncertainties that different stakeholder groups believe are present in GM food and crops.

9.3 Key messages

There are five key messages that arise from the research that are of relevance for moving forward the GM debate.

First, as there are socio-demographic and cultural factors linked to the perceptions of risk associated with GM technologies in food and agriculture, it is important to recognise that different people will react differently to the technology. Specifically, results from this thesis show that it may be men, those who are more highly educated, those with a less ecocentric worldview, and those living in urban areas, who are likely to respond more favourably to targeted promotional campaigns. As regards the farming community, results show that the first farming adopters are likely to be those who are both owners and tenants, not in an urban fringe location, potato growers, and not barley growers.

Second, this thesis provides evidence that third parties are particularly important to farmers, thus it is crucial to recognise that there is potentially a long chain of action and reaction amongst many different stakeholders and actors impacting on farmers' levels of risk perception, and hence willingness to adopt the technology.

Third, results from this research demonstrate that the linked issues of the relationship between risks and benefits, and the equity of (positive and negative) impacts, require that all stakeholders are content that they will receive a share of the benefits (if any) to be derived from the technology, and that neither they nor any other group of stakeholders are unduly impacted by the risks or negative impacts (if any) of the technology. Important here is the recognition that perceptions are as important as actual impacts.

Fourth, the issue of trust has been shown by the results obtained by this research to be extremely important to peoples' perceptions of risk. It can be concluded that trust is of wider social and political importance that relates to the need to ensure greater democratisation of decision-making in order to re-establish trust in authorities. In the case of GM food this may require a rethinking of the EU legislation relating to the technology. This also relates to point below about the delivery of messages and education. Information sources must be trusted by those at whom the messages are aimed. More importantly though, if people are to trust decision making processes, there needs to be stakeholder involvement at an early stage of decision making, that allows some impact on decisions taken. In the case of the GM debate it may indeed be too late as decisions about the technology, its applications, the regulatory processes and its inclusion within the food chain are well established. Perhaps the best that can be hoped for is that lessons will be learnt and applied to future technology developments of relevance to the food chain, such as, nano-technology.

Finally, this thesis has shown that uncertainty is central to peoples' perceptions of risk. This could be addressed through a combination of additional research into what is uncertain to people, the impacts and implications of the technology, more effective dissemination of existing knowledge, and impartially delivered messages and education strategies from trusted sources that address the concerns that people have about the technology. Importantly however there must be an acknowledgement that uncertainty is not restricted to 'knowledge deficit' but encompasses the scientific uncertainties inherent within the technology, and is framed by the social and cultural values of those whose views are considered.

9.4 Conclusions

This thesis uniquely targeted diverse groups and employed a combination of different methods from a variety of disciplines. By doing this the study has increased understanding of the views of two groups (campaigners and farmers) who are crucial to the uptake of the technology, and who are seldom researched in the area of attitudes to GM technologies.

The diversity of groups, methods and disciplines brought together in this thesis is important because the issue of GM has proved to be complex and far-reaching, and previous discussions of risk perceptions have been complex and disjointed. All groups investigated here are stakeholders in the process, and as such their views and concerns relating to risk perceptions of GM technologies ought to be taken into consideration.

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Appendices

Appendix one: Protester postal survey

Postal survey sent to members of anti-GM and environmental campaign groups in Scotland

Genetically modified food and crops in Scotland: s of risks and benefits

On the following pages there is a short survey about GM food. This survey is being carried out by the Scottish Agricultural College in Edinburgh, with funding from the Scottish Executive, to find out what perceptions you have about the risks and benefits of GM food and crops.

It is part of a larger project investigating risk perceptions relating to food, and will be used to inform the ongoing GM debate and wider issues relating to public attitudes to food risk.

Your answers will be important for the success of the project and I hope you will be able to take a few moments to complete the survey (it should take about 15 minutes).

If you would like to take this opportunity to have your say, please return the survey in the Freepost envelope attached, if possible within two weeks of receiving it.

If you prefer, the completed survey can be returned by fax:
0131 667 2601

An on-screen version of the survey is also available. Please email Clare Hall at c.r.hall@ed.sac.ac.uk

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SECTION ONE: ENVIRONMENTAL VALUES

Below are 10 statements about peoples' relationship with the rest of the environment. This section will investigate how eco-centred or human-centred your view of the world is. One aim of the survey will be to see how your 'worldview' influences your perceptions of the risks and benefits of GM technology.

- Tick one box to indicate to what extent you agree or disagree with each statement.

DO YOU AGREE OR DISAGREE WITH THE STATEMENTS BELOW?	STRONGLY DISAGREE	PARTIALLY DISAGREE	PARTIALLY AGREE	STRONGLY AGREE
1) Humans have the right to modify the environment to suit their needs	☐	☐	☐	☐
2) When humans interfere with 'nature' it often produces negative consequences	☐	☐	☐	☐
3) Human ingenuity will ensure that we do not make the earth uninhabitable	☐	☐	☐	☐
4) Human behaviour is damaging the environment	☐	☐	☐	☐
5) The environment is able to adapt to cope with the impacts of industrial societies	☐	☐	☐	☐
6) Plants and animals have as much right to exist as human beings	☐	☐	☐	☐
7) The so-called ecological crisis facing the planet has been exaggerated	☐	☐	☐	☐
8) Despite our greater intelligence humans are still subject to the 'laws of nature'	☐	☐	☐	☐
9) Humans were meant to have stewardship over the rest of the environment	☐	☐	☐	☐
10) The balance of nature is fragile and easily disturbed	☐	☐	☐	☐

SAC GM food risk and benefit survey

SECTION TWO: RISKS AND BENEFITS RELATING TO CURRENT GM TECHNOLOGIES

Below are twelve questions about GM crops and food NOW.

These have been written after an extensive search of previous surveys and claims that have been made about GM technology in food.

- **For each question circle one number on the scale. Please only mark the 'unsure' box if you really don't know.**

1) How much control do you think Scottish residents had over their own exposure to GM crop trials in Scotland?	A lot of control	1	2	3	4	5	No control at all	Unsure ☐
2) How much benefit do you think there is for Scottish consumers from the current applications of GM technology to food production?	No benefit at all	1	2	3	4	5	A lot of benefit	Unsure ☐
3) How much control do you think Scottish consumers have over their own exposure to GM food ingredients?	A lot of control	1	2	3	4	5	No control at all	Unsure ☐
4) How much benefit do you think people in developing countries gain from the application of current GM technology to food production?	No benefit at all	1	2	3	4	5	A lot of benefit	Unsure ☐
5) How much of a health risk do you think there is to Scottish consumers from eating products containing GM ingredients?	No risk at all	1	2	3	4	5	A lot of risk	Unsure ☐
6) How much economic benefit do you think there is for farmers in other countries who grow commercial GM crops with built-in pesticide?	No benefit at all	1	2	3	4	5	A lot of benefit	Unsure ☐
7) To what extent do you think herbicide resistant plants grown in Scottish GM crop trials might have cross-bred with 'wild' relatives?	Not at all	1	2	3	4	5	To a large extent	Unsure ☐
8) To what extent do you think growing commercial GM crops with built-in pesticide (in other countries) reduces the need for agri-chemicals?	No reduction at all	1	2	3	4	5	Large reduction	Unsure ☐
9) To what extent do you think the crops of Scottish organic farmers were at risk of contamination from GM plants grown in Scotland as part of GM crop trials?	No risk at all	1	2	3	4	5	Large risk	Unsure ☐
10) To what extent do you think growing commercial herbicide-resistant GM crops in other countries (which leads to better targeting of herbicides) reduces agri-chemical use?	No reduction at all	1	2	3	4	5	Large reduction	Unsure ☐
11) How much of a health risk do you think there was for individuals living in Scotland in the vicinity of GM crop trials?	No risk at all	1	2	3	4	5	A lot of risk	Unsure ☐
12) How much economic benefit do you think there is for biotechnology companies such as Bayer and Monsanto from commercial GM crops grown in other countries?	No benefit at all	1	2	3	4	5	A lot of benefit	Unsure ☐

SECTION THREE: RISKS AND BENEFITS RELATING TO FUTURE GM TECHNOLOGIES

Below are twelve questions about GM crops and food IN THE FUTURE.

These have been written after an extensive search of claims that have been made about GM technology in food.
Remember that these questions refer to the future so you need to think about what the situation <u>will be</u> in the future.

- For each question <u>circle one number</u> on the scale. Please only mark the 'unsure' box if you really don't know.

Question	Scale	Unsure
1) To what extent do you think public opinion will be considered before decisions are made about commercial establishment of GM crops in Scotland?	A lot 1 2 3 4 5 Not at all	Unsure ☐
2) To what extent do you think Scottish consumers will benefit from the development of GM technologies to improve the flavour of food products?	Not at all 1 2 3 4 5 A lot	Unsure ☐
3) To what extent do you think Scottish consumers will be able to choose whether or not to buy GM food products?	A lot of choice 1 2 3 4 5 No choice	Unsure ☐
4) To what extent do you think people in developing countries will benefit from the production of GM crops with added vitamins?	Not at all 1 2 3 4 5 A lot	Unsure ☐
5) To what extent do you think there will be health risks for Scottish consumers from eating GM food products and ingredients?	No risks 1 2 3 4 5 A lot of risks	Unsure ☐
6) To what extent do you think the production of GM food items with increased shelf life (which will reduce wastage) will create cost savings for Scottish consumers?	Not at all 1 2 3 4 5 A lot	Unsure ☐
7) To what extent do you think there will be unpredictable negative impacts on the environment in Scotland from the commercial planting of GM crops?	No impacts 1 2 3 4 5 A lot of impacts	Unsure ☐
8) To what extent do you think yield-increasing GM species will help preserve or re-instate 'natural' habitats throughout the world by reducing the need for agricultural land?	Not at all 1 2 3 4 5 A lot	Unsure ☐
9) To what extent do you think there will be a risk to Scottish arable farmers (organic and conventional) of contamination from commercial GM crops?	Not at all 1 2 3 4 5 A lot	Unsure ☐
10) To what extent do you think the introduction of commercial GM crops with built-in pesticide will reduce the use of agri-chemicals in Scotland?	Not at all 1 2 3 4 5 A lot	Unsure ☐
11) To what extent do you think Scottish residents will face health risks from the commercial planting of GM crops?	No health risks 1 2 3 4 5 A lot of risk	Unsure ☐
12) To what extent do you think the development of drought resistant species will create economic benefits for farmers in developing countries?	Not at all 1 2 3 4 5 A lot	Unsure ☐

SECTION FOUR: RISK LADDER

Although many people think that the risks of GM are largely unknown, we would like to get some idea of how risky you feel GM food is likely to be relative to other known health risks.
The risk ladder below shows a number of health issues and risky events that pose a danger to health. The list is arranged with the most risky at the top and least risky at the bottom.
Write 'GM' at a point on the ladder that reflects how risky you feel GM food is likely to be to the health of people in Scotland. You can add 'GM' at any point above or below any of the issues listed or next to one if you feel it is equally as risky as something else.

Risky event or health issue

Most risky

…………………………………………..

Cancer

…………………………………………..

Heart disease

…………………………………………..

Accidents in general (including at home, at work, on the street and so on)

…………………………………………..

Accidents in the home

…………………………………………..

Road accidents

…………………………………………..

Food-borne illness (such as food poisoning)

…………………………………………..

Variant CJD (human form of 'mad cow disease')

…………………………………………..

Food-related anaphylactic shock (allergic reaction eg in connection with peanuts)

…………………………………………..

Least risky

SECTION FIVE: DEMOGRAPHIC INFORMATION

This additional information will help us to evaluate the results of the survey in more depth. Please be assured that any information you supply will be held in confidence, will remain anonymous and used only for evaluating the results of this survey.

Please tick the relevant option in each question.

Are you… O Female O Male

What year were you born?……………………………………………………………..

What is the highest level of educational qualifications that you have?

O No formal qualifications O HNC O HND

O O grades / O levels / CSEs / GCSEs O Highers / A levels

O Undergraduate degree O Postgraduate degree O Other

Are you … *O Living alone* *O Living with partner / spouse without children*

O Single parent O Living with partner / spouse and children

O Living in extended family household O Living in shared accommodation

O Other

Would you describe the place you live in as…

O Large urban area (more than 125,000 people) O Urban area (10,000 – 125,000 people)

O Accessible small town (3,000 – 10,000 people. Within 30 minutes drive of a settlement of 10,000 people or more)

O Remote small town (3,000 – 10,000 people. More than 30 minutes drive to settlement of 10,000 people or more)

O Accessible rural (Less than 3,000 people. Within 30 minutes drive of a settlement of 10,000 people or more)

O Remote rural (Less than 3,000 people. More than 30 minutes drive to settlement of 10,000 people or more)

Do you live near to a field where there were GM trials ? O Yes O No O Don't know

What gross annual income bracket does your household come under (figures are per year, before tax deductions)?

O *Under £10,000*	O *£10,001 - £20,000*	O *£20,001 - £30,000*
O *£30,001 - £40,000*	O *£40,001 - £50,000*	O *Over £50,000*

Many thanks for taking the time to complete the survey

SAC GM food risk and benefit survey

Appendix two: Risk and benefit questions and responses

Percentage responses to all risk and benefit statements

Question	Unsure	A lot of control	Some control	Neutral	Very little control	No control at all
How much control do you think residents had over their own exposure to GM crop trials in the UK?	28.9	-	2.6	7.9	23.7	36.8
How much control do you think consumers in the UK have over their own exposure to GM food ingredients?	28.9	2.6	5.3	18.4	34.2	10.5
	Unsure	**No risk at all**	**Very little risk**	**Neutral**	**Some risk**	**A lot of risk**
How much of a health risk do you think there is to UK consumers from eating products containing GM ingredients?	42.1	2.6	13.2	13.2	10.5	18.4
To what extent do you think the crops of organic farmers were at risk of contamination from GM plants grown in the UK as part of GM crop trials?	34.2	2.6	2.6	-	28.9	31.6
How much of a health risk do you think there was for individuals living in the UK in the vicinity of GM crop trials?	34.2	15.8	21.1	10.5	10.5	7.9
	Unsure	**Not at all**	**Very little**	**Neutral**	**To some extent**	**To a large extent**
To what extent do you think herbicide resistant plants grown in GM crop trials in the UK might have cross-bred with ‘wild’ relatives?	36.8	-	-	13.2	18.4	31.6

Question	Unsure	No benefit at all	Very little benefit	Neutral	Some benefit	A lot of benefit
How much benefit do you think there is for UK consumers from the current applications of GM technology to food production?	28.9	52.6	15.8	2.6	-	-
How much benefit do you think people in developing countries gain from the application of current GM technology to food production?	28.9	44.7	18.4	5.3	2.6	-
How much economic benefit do you think there is for farmers in other countries who grow commercial GM crops with built-in pesticide?	31.6	26.3	21.1	10.5	7.9	2.6
How much economic benefit do you think there is for biotechnology companies such as Bayer and Monsanto from commercial GM crops grown in other countries?	34.2	-	-	5.3	5.3	55.3
	Unsure	**No reduction at all**	**Very little reduction**	**Neutral**	**Some reduction**	**Large reduction**
To what extent do you think growing commercial GM crops with built-in pesticide (in other countries) reduces the need for agri-chemicals?	34.2	21.1	23.7	13.2	7.9	-
To what extent do you think growing commercial herbicide-resistant GM crops in other countries (which leads to better targeting of herbicides) reduces agri-chemical use?	36.8	21.1	23.7	13.2	5.3	-

Question	Unsure	A lot	Some	Neutral	Very little	Not at all
To what extent do you think public opinion will be considered before decisions are made about commercial establishment of GM crops in the UK?	34.2	2.6	5.3	15.8	26.3	15.8
To what extent do you think there will be a risk, to arable farmers (organic and conventional) in the UK, of contamination from commercial GM crops?	28.9	52.6	15.8	-	2.6	-
	Unsure	**A lot of choice**	**Some choice**	**Neutral**	**Very little choice**	**No choice**
To what extent do you think consumers in the UK will be able to choose whether or not to buy GM food products?	31.6	2.6	10.5	10.5	39.5	5.3
	Unsure	**No risks**	**Very little risk**	**Neutral**	**Some risks**	**A lot of risks**
To what extent do you think there will be health risks for UK consumers from eating GM food products and ingredients?	34.2	-	23.7	13.2	7.9	21.1
	Unsure	**No impacts**	**Very little impact**	**Neutral**	**Some impacts**	**A lot of impacts**
To what extent do you think there will be unpredictable negative impacts on the environment in the UK if GM crops are grown commercially?	31.6	-	-	-	21.1	47.4
	Unsure	**No health risks**	**Very little risk**	**Neutral**	**Some risk**	**A lot of risk**
To what extent do you think UK residents will face health risks from the commercial planting of GM crops?	31.6	2.6	23.7	10.5	18.4	13.2

Question	Unsure	Not at all	Very little	Neutral	Some	A lot
To what extent do you think consumers in the UK will benefit from the development of GM technologies to improve the flavour of food products?	31.6	60.5	7.9	-	-	-
To what extent do you think people in developing countries will benefit from the production of GM crops with added vitamins?	34.2	34.2	15.8	10.5	5.3	-
To what extent do you think the production of GM food items with increased shelf life (which will reduce wastage) will create cost savings for consumers in the UK?	39.5	36.8	15.8	5.3	2.6	-
To what extent do you think yield-increasing GM species will help preserve or re-instate 'natural' habitats throughout the world by reducing the need for agricultural land?	36.8	52.6	5.3	2.6	2.6	-
To what extent do you think the introduction of commercial GM crops with built-in pesticide will reduce the use of agri-chemicals in the UK?	31.6	31.6	26.3	10.5	-	-
To what extent do you think the development of drought resistant species will create economic benefits for farmers in developing countries?	31.6	18.4	18.4	18.4	13.2	-

Appendix three: Farmer postal survey

Genetically modified crops postal survey sent to farmers in Scotland

Genetically modified crops survey

PLEASE RETURN COMPLETED SURVEY TO CLARE HALL,
Land Economy Research, SAC, Kings Buildings, Edinburgh, EH9 3JG
IN THE ENVELOPE PROVIDED

Completing the survey: One or two short sentences in each box is all that is required but write as much as you wish and use extra paper if the box is too small.

1) What do you understand by the phrase 'genetically modified crops'?

2) Do you think the introduction of genetically modified crops into Scottish agriculture would be good or bad for Scottish farming? Please explain your answer in as much detail as you can.

3a) What do you think will be the main problems (if any) presented by the introduction of genetically modified crops in Scotland?

3b) Who will experience these problems (if you think there will be any)?

4a) What do you think will be the main advantages (if any) arising from the introduction of genetically modified crops in Scotland?

4b) Who will benefit from the advantages (if you think there will be any)?

5) How do you think genetically modified crops might impact on farmland wildlife (if at all)? (This could be good and / or bad impacts).

6) What problems (if any) do you think could arise from the existence of both genetically modified crops and non-genetically modified crops in Scotland?

7a) Some people are concerned that genetically modified plants will find their way into non-genetically modified crops.
If genetically modified crops are grown in Scotland, do you think that contamination of non-genetically modified crops will be a problem? Please explain your answer.

7b) If you do think that contamination of non-genetically modified crops will be a problem, how do you think it should be dealt with?

8) What do you think people (other farmers and non-farmers) might feel about a farm nearby deciding to grow genetically modified crops?

9a) What factors might encourage you to grow genetically modified crops?

9b) What factors might discourage you from growing GM crops?

10a) A number of genetically modified crops have already been approved for cultivation in the European Union but are not currently grown in the UK. Some predictions are that the first commercial cultivation of genetically modified crops in the UK is not likely until perhaps 2008.
If a genetically modified variety of the main crop(s) you currently produce was/were to be available for commercial planting in 2008 would you choose to grow it/them or not?

Yes / No / Don't know *   (*Delete as appropriate)

10b) What are the reasons for your answer to the previous question?

Details about you and your farm

What is the size of your farm (hectares)?……………………………………….

What is/are the main crop(s) you grow?…………………………………………

How many years have you been farming?…………………..…………………

Are you a farm owner / tenant*?

What is your age group? (please circle)

20-29 30-39 40-49 50-59 60-69 70 or over

Are you Male / Female?*

Did you take over the management of the farm from a previous generation of your family?

Yes / No*

Will you pass on management of the farm to a future generation of your family?

Yes / No / Maybe*

* Delete as appropriate

The second stage of the research

☐ Please tick if you might be interested in being involved in stage two of the research (this will be a face to face interview conducted at a location convenient for you)

And, if so, then please indicate which is the best way to contact you:

☐ Phone (and the best time is: Morning / Afternoon / Evening / No specific time*)

☐ Fax

☐ Letter

☐ Email

☐ Any

Please provide relevant contact details if you are interested in being involved in the next part of this project:

Thank you for taking the time to complete the survey!

Appendix four: 48 statements used for Q sorting exercise

48 statements selected for use in Q sorting exercise with farmers

Possible position / **Thematic element**	***GM positive***	*GM negative*	*Unsure or neutral*
Overall view of GM	All growers would benefit if GM crops were introduced to Scotland	It would be better if Scotland is seen to be GM free	I don't know who would benefit if GM crops were introduced in Scotland
Crop management	I might be encouraged to grow GM crops by the fact that the modified plants may be easier to treat for mildew and many of our common everyday problems Farmers would benefit from lower costs and increased yields if GM crops were introduced in Scotland	Problems arising from the introduction of GM crops would impact on farmers who will have fields of crops they cannot get rid of Problems arising from the introduction of GM crops would impact on farmers as they are perceived as being custodians of land and are easiest to target	I can't say what factors might encourage me to grow GM crops – it will depend on the features produced by the GM and which crop it is The introduction of genetically modified crops into Scottish agriculture would be good for Scottish farming provided the correct characteristics are introduced e.g. disease control
Consumer opinion / demand / market	I might be encouraged to grow GM crops if there was demand from consumers Personally I can see no reason for not having GM crops other than the problem of bad publicity Interference from activists to trial crops should be dealt with severely in the law courts as the activists are only hindering the interests of mankind	I would be discouraged from growing GM crops by the risk of having groups of objectors arriving on our farm If a farm nearby decided to grow genetically modified crops I would not be happy as I would not want my soil contaminated with GM pollen. I should have the right to decide what happens on my land The existence of both genetically modified crops and non-genetically modified crops in Scotland would mean that the natural, largely organic, good food image of Scotland would be jeopardised	I am not sure whether the introduction of genetically modified crops into Scottish agriculture would be good or bad for Scottish farming but until the public is in favour of GM crops they are a non-starter I don't know if I would choose to grow GM crops. It would depend on press coverage I think the introduction of genetically modified crops into Scottish agriculture would be bad for Scottish farming but only because the public perceive it as bad
Environment / wildlife	The introduction of GM crops in Scotland should benefit wildlife because there is the potential for less spray to be needed I might be encouraged to grow GM crops by	Problems arising from the introduction of GM crops would impact on the environment, that in turn affects everyone and everything We have already seen a reduction in wildlife	I'm not sure if the introduction of GM crops is likely to be a problem but there may be a problem with the surrounding environment, i.e. insects, birds and wildlife

	clearly demonstrated advantages and no long or short term risks to environment	species due to natural habitat loss – GM crops would exacerbate this problem	I don't know how GM crops might impact on farmland wildlife but wildlife is pretty adaptable
Costs / finances	I would choose to grow GM crops if there was a bigger margin for growing them The introduction of genetically modified crops into Scottish agriculture would be good for Scottish farming in as much as it may reduce costs of growing them	I don't think there is any need for genetically modified crops as we are struggling to get a decent price for what we grow I would not choose to grow GM crops because crops grown in countries which are completely GM free may get higher prices due to consumer demand	The only advantage I can see from introducing GM crops would be being able to produce a crop at a lower cost, but this, as with all crop marketing, will just force us to take a lower price I might be encouraged to grow GM crops when every one else is and the profitability of the crop make it necessary to go with the tide
Information / Safety	If proven 'safe' the introduction of genetically modified crops into Scottish agriculture would be good for Scottish farming	I would not choose to grow GM crops because the risks are unknown and future generations should not be put at risk	I don't know if I would choose to grow GM crops because I still need to be convinced it is safe and not just commercial
Co-existence	I don't believe there would be any problems arising from the existence of both genetically modified crops and non-genetically modified crops in Scotland I cannot understand the argument about contamination of GM crops - cross pollination or contamination are emotive words and we have always accepted it I don't believe there is any difference in quality / safety of eating either GM or non-GM so cross-contamination would not be a problem	*Contamination of non-GM crops by GM crops should be dealt with by crop destruction* The existence of both genetically modified crops and non-genetically modified crops in Scotland would lead to cross pollination and this must not be allowed to happen Don't introduce GM crops - we are an island, we may be able to trade worldwide on our GM-free status	The existence of both genetically modified crops and non-genetically modified crops in Scotland would lead to problems for the purity of non-GM product but this is only relevant if a market continues to exist for guaranteed non-GM produce and that may become doubtful I don't think there is a place for both GM crops and non-GM crops – it will have to be either one or the other *I do not think contamination of non-GM crops by GM crops can be prevented and it would just have to be accepted*

Technology	I would choose to grow GM crops because technology should be embraced In future we may be able to grow GM crops for specific purposes or in conditions other than their natural environments which could be an advantage	The main problem that would arise from the introduction of genetically modified crops in Scotland would be that it would reinforce the existence of input-dependent industrial agriculture Introducing GM crops may mean more attractive-looking products like bright red smooth tomatoes, although this may put buyers off because they will look as if they are GM and not natural	There would be very few advantages to the farmer from the introduction of GM crops in Scotland but if a nitrogen fixing gene could be implanted in cereals, together with disease resistance (drought tolerance) then long term security of supply of food with low oil based inputs could be guaranteed If only ‘natural’ genes are added to GM plants then it’s ok but if it involves using genes from a different species then it’s not ok